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Vernon Bernard Mayrose
Iowa State University

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EFFECT OF FEEDING LEVELS ON THE REPRODUCTIVE PERFORMANCE OF SWINE

by

Vernon Bernard Mayrose

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Head of Major Department

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Dean of Graduate College

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INTRODUCTION

A successful swine enterprise depends in part on the efficient reproductive performance that is obtained from the breeding herd. Costs of maintaining a breeding herd represent approximately thirty percent of the total costs of a swine enterprise, and an improvement in the efficiency of the operation is considered a worthwhile endeavor.

The objective of reproduction in pigs is to obtain the largest number and weight of weaned pigs per sow. About ninety percent of the variation in litter size is attributed to environmental effects and about ten percent due to the heritability of this trait. In this study an attempt was made to reduce the experimental error caused by within group environmental factors, or all factors other than genetic, such as nutritional, managerial, social, and psychological. Coupled with sizeable numbers it was hoped that more valid conclusions could be made in this reproductive study.

Research has shown in some cases that a greater ovulation rate occurs in gilts fed on a high plane of nutrition, however, a higher embryo death loss may occur in this system. A management practice of flushing prior to breeding and then reducing feed intake has been advocated. Some recent evidence indicates, however, that animals can be maintained on a lower plane of nutrition without hindering reproductive performance.

The purpose of this research was to study the effects of two levels of feed intake during two periods of the reproductive cycle in swine, prior to and during the mating period and during the last one-third of gestation.

LITERATURE REVIEW

Effects of the Feeding Regimen on Reproduction

Some of the early studies on feeding and reproduction with farm animals began about 1916, and were carried out by the United States Department of Agriculture by Marshall and Potts (1921). These studies were carried out using breeding ewes in an effort to determine the effects of different feeding plans upon the lambing rate. The term "flushing" is used to indicate an increase in the plane of nutrition prior to the breeding season. With sheep the practical advantage of flushing lies in the production of twins which in turn depends upon the number of ova produced by the ewe. An average increase of 18.1 percent in the number of lambs at parturition was obtained as a result of flushing in these experiments.

Somewhat later McKenzie and Terrill (1937) found that ewes kept on a low plane of nutrition had a shorter breeding season, longer estrual cycles, shorter preovulatory periods and lower ovulation rates, but showed no difference in the duration of estrus when compared with similar ewes kept on a high plane of nutrition.

Bellows *et al*. (1963) found a highly significant breed difference in ovulation rate in favor of Hampshire ewes when compared to the Columbia ewes. Flushing produced a significant increase in ovulation rate in the Columbia but not in the Hampshire ewes. Grain feeding during gestation increased all fetal body characters measured in both single and twin fetuses. In addition, an age difference was suggested between yearling and mature ewes of the same breed in response to flushing, embryo survival and feed effects on fetal growth.

Some of the first studies with swine were reported by McKenzie (1928). These first observations showed that the lowest gains of the sows during pregnancy, 0.5 to 0.6 pounds per day were associated with lowest total litter weights 7.7 to 13.6 pounds. The sow's loss in weight at parturition was greatest for the better fed sows, 43 pounds, and these sows also farrowed the heaviest litters, 26.6 to 31.8 pounds. A severe loss of weight prior to breeding (one pound daily) was associated with smaller litters. There was a direct relationship between daily gains made the four weeks after the sows settled and number of pigs farrowed. This same relationship was found to hold for the gains made throughout gestation, but is not so clear-cut as it is in the first month of pregnancy. The data presented would indicate that the gains made by these sows the two weeks prior to breeding had little influence on the size of the litter.

A tendency for the number of pigs farrowed to increase with the increased rate of gain of the sow during gestation was observed by Zeller *et al.* (1937) in studies with 658 sows covering a period of nine years. It was found that as the rate of daily gain of the sow increased during gestation there was an increasingly greater loss in weight of the sow during suckling. Also, the heavier sows farrowed larger litters and weaned more and heavier pigs.

Robertson et al. (1951) found that gilts full-fed from 70 days of age ovulated 1.1 eggs more per gilt than did gilts fed 70 percent of the amount the full-fed group received, however, limited-fed gilts tended to have more embryos at 25 days of gestation than the full-fed gilts. When compared on a percentage basis the limited-fed gilts had a significantly greater percent of corpora lutea represented by normal embryos than did the full-fed animals, 67 percent versus 43 percent, respectively.

The ovulation rate for gilts allowed feed ad libitum was higher than for gilts fed 70 percent of full feed, 15.1 versus 13.4, respectively. In this experiment Christian and Nofziger (1952) observed, however, that for fertilization rate the reverse was true, 83.2 percent for high plane and 85.5 percent for the low plane gilts. The high plane gilts farrowed fewer live pigs and had a higher prenatal death rate than the low plane gilts, 4.7 and 62.9 percent versus 7.4 and 35.3 percent, respectively. The embryonic loss was greater for the high plane gilts that showed a higher ovulation rate compared to the gilts that were limited-fed.

Hanson et al. (1953) observed that gilts self-fed during gestation farrowed more and heavier pigs and weaned heavier pigs than did gilts that were limited in feed intake, 8.23, 2.85, 31.7 versus 7.0, 2.63, 27.5, respectively. In another study by Hanson *et al.* (1956), limited-fed gilts weighed 322 pounds at farrowing compared to 425 pounds for the self-fed group. The number of live pigs farrowed was slightly higher for the self-fed group, however, the survival rate was higher for the limited-fed group, and so the number of pigs weaned per gilt turned out to be the same for both groups.

Self *et al.* (1955) subjected gilts to different sequences of feed levels consisting of either self-fed, or hand-fed at two-thirds the full-fed rate. The experimental period was divided into a prepuberty phase starting when gilts were about 70 days of age, a first estrual cycle phase, and from second heat (when all gilts were bred) until the 25th day of gestation. Continuous full feeding was superior to continuous limited feeding for ovulation rate, but was inferior for percent embryo survival and number of embryos present. The effect of short periods of either full or limited feeding just prior to breeding on the 25-day litter size was approximately the same as continuous feeding on the same level. Ovulation rate was more susceptible to alteration than embryo survival.

Waldorf *et al.* (1956) in a study with 80 litters of 102 to 108 day-old fetuses from gilts and sows found no definite evidence to indicate that variation in litter size has any effect on fetus weight other than that exerted by the number of pigs in a horn. The pigs at the extremes of a uterine horn tended to be larger than those toward the middle.

Baker *et al*. (1956) sacrificed 119 gilts on the 25th day of pregnancy and 26 gilts on the 70th day of pregnancy. Embryo survival to the 25th day was 57 percent, and to the 70th day 50 percent. The analysis of the direct effects (by standard partial regression) of ovulation rate and embryo survival on litter size indicated that survival rate is far more important than ovulation rate (25 day:0.97 versus 0.28; 70 day:1.03 versus 0.35).

Haines *et al*. (1957) started with gilts weighing 100 pounds that were full-fed a growing ration until their second estrus at which time all gilts were bred. After breeding, one-half of the gilts remained on full feed and one-half of them received 50 percent of the energy in the full-fed ration. In addition, one half of the gilts on each ration were given 25 milligrams of progesterone every other day during the first 25 days of gestation. Neither ration nor hormone treatment had a significant influence on the number of embryos present at slaughter or on the number of live pigs farrowed. However, the stage of gestation showed a significant influence on the number of embryos and live pigs. At 25 days, 40 days and term, there were 11.8, 10.0 and 6.9 embryos and pigs, respectively. The differences in embryonic survival due to the stage of gestation, ration and hormone treatment were not significant. In another study a difference in reproductive performance was observed in gilts by Haines *et al*. (1959a). One-half of the animals were self-fed, and one-half were fed a ration containing 50 percent of the energy, but with the same amount of essential nutrients. On their first heat, full-fed gilts ovulated 2.9 more ova and had a 10 percent greater fetal mortality compared to limited-fed gilts. Results of this study indicate that restricting the energy intake delayed puberty, depressed ovulation rate and decreased embryonic mortality. Haines et al. (1959b) found that the gonadotropic content of pituitaries from gilts sacrificed at 3 days postbreeding was not sufficient to produce a significant response in a chick assay. Pituitary glands from gilts pregnant for 25 days possessed a significantly greater gonadotropic content than those from gilts killed 3 days postbreeding. The ration treatment to which the gilts were subjected did not affect the gonadotropic content of their pituitary glands.

A therapeutic approach has been developed in regard to the problem of embryonic mortality which alters favorably the uterine environment during certain initial stages of pregnancy. Research by Reddy et al. (1958) revealed that a progesterone-estrogen therapy in the form of daily injections of 25 milligrams of progesterone plus 12.5 micrograms of estrone per gilt for ten consecutive days beginning on the fourteenth day of gestation apparently provided a more favorable uterine environment since the embryonic mortality was reduced. Embryonic mortality for this treatment was 13.5 percent. Three other treatment groups showed percentages of 21.7, 18.8, 18.2 compared to 23.3 percent mortality in the non-treated group of gilts.

Hafez (1958) and Fowler and Ensminger (1961) full-fed one group of gilts from weaning to 150 pounds and another group was fed only 70 percent of this amount. From 150 pounds until farrowing, all pigs were hand-fed. High-plane animals received enough feed to permit an average daily gain of 1.5 to 2.0 pounds and the low-plane pigs received 70 percent of this amount. After farrowing, the high-plane sows returned to full-feed and the low-plane sows received 70 percent of full-feed. After six generations, one-half of the pigs in each group were shifted to the other plane of nutrition forming four groups: high-high, low-low, low-high and high-low. Ovulation rate in the high-high group was significantly higher than in the other groups. Implantation occurred in 77.3, 72.7, 64.5 and 48.2 percent of the ova in the low-low, high-low, high-high and low-high groups, respectively. There were no significant differences in weight of corpus luteum, pituitary, adrenals, embryo or amniotic fluid or length of oviduct or length of crown/rump.

The average age that gilts reached sexual maturity was found to decrease an average of 6 days on restricting the energy of the ration compared to those not restricted in a study by Day (1959). Low energy restricted gilts weighed an average of 21 pounds less than their full-fed relatives at time of puberty. Sexual receptivity at the time of breeding was found to be more pronounced and more regular in occurrence in the limited-fed gilts, and they also showed fewer reproductive aberrations. Average ovulation rates and the average number of living embryos present on the 25th day of gestation for the two treatment groups were approximately the same. The average number of corpora lutea of the full-fed and limited-fed gilts were 10.3 and 11.7, respectively.

Gossett and Sorensen (1959b) self-fed rations containing two levels of energy (93 versus 55 therms of productive energy per pound) to gilts with an average initial weight of 44 pounds. When the gilts were slaughtered forty days after they were bred at second estrus, the lower energy group was found to have a greater number of normal living embryos and a higher percent of living embryos present. In addition, the lower energy group reached puberty earlier. The ovulation rates were comparable to gilts receiving the control or higher energy ration. Further studies by Sorensen _et al_. (1961) using similar experimental procedures again found that the gilts on the low energy ration had a significantly greater percent of live embryos at forty days than gilts fed the high energy ration, 71.8 versus 56.9 percent, respectively. There was no difference between treatments in the number of live embryos, however, the gilts fed the high energy ration did average 1.3 more ova shed than the gilts on the low energy rations. Gossett and Sorensen (1959a) also indicate that at 40 days post-breeding an additional five percentage points of mortality were found as compared to 25 days postbreeding.

Limited-fed gilts (4 pounds per head per day) farrowed more pigs per litter than did normal-fed gilts (6 pounds per head per day) with no difference observed in the average birth weight. However, in two other trials, Dean and Tribble (1959) found that the normal-fed gilts farrowed more pigs that were slightly heavier at birth than the limited-fed gilts. Limited-fed sows consumed an average of 209 pounds less feed than the normal-fed sows for the gestation and lactation periods combined. Sows fed the normal level gained more during gestation and lost more weight during lactation than did limited-fed sows. Backfat probes revealed that normal-fed sows increased, and limited-fed sows decreased in fatness during gestation. In two out of three trials, the limited-fed sows showed an increase in backfat during lactation, and in all three trials the normal-fed sows were fatter when their pigs were weaned than the limited-fed sows. Each increase of one millimeter in backfat thickness during gestation was associated with a decrease of 0.15 pigs per litter.

In New Zealand, Smith (1960) used two groups of Berkshire sows in a study that involved feeding different amounts of a ration during pregnancy so that the average weight gain of the high plane group was 114 pounds, while that of the low-plane group was 60 pounds before parturition. Average number born per litter was 8.6 on the high plane and 9.4 on the low. During lactation high plane sows lost an average of 74 pounds and the low plane 54 pounds.

Gilts started on experiment at between 100 to 130 pounds and fed a high energy diet attained puberty earlier and had a higher daily gain than gilts on a low energy diet in a study completed by Goode et al. (1960). In the low energy ration oats and alfalfa meal were substituted for corn and soybean meal. The average ovulation rates at the first and second heat periods were 11.3 and 13.5 for gilts on the high energy diet compared with 11.4 and 14.1 for those on the low energy diet. The number of normal embryos in gilts slaughtered at 25 days postbreeding averaged 9.1 and 10.5 for the high and low energy treatments, respectively.

In 1960, Self et al. conducted further studies on reproduction. In this study they developed weanling pigs on pasture and fed three different levels of feed intake, full-fed, two-thirds full feed and one-third full feed. All lots were full-fed from 2 to 3 weeks prior to the start of mating until 3 to 4 days following mating when they returned to their respective levels of approximately 6.0, 4.5, and 3.0 pounds of ration per head daily. Litter size, birth weight, weaning weight and number of pigs weaned were not significantly affected by feeding level.

Zimmerman et al. (1960) flushed gilts for 6, 10 or 14 days prior to their second heat by switching from a 13 percent fiber ration to a 6 percent fiber ration. An increase of 2.8, 3.2 and 3.9 ova were found, respectively, for the 6, 10 or 14 day flushing period compared to an increase of 1.5 ova for unflushed gilts. In another study gilts were fed individually twice daily 2.5 percent of the lot average body weight, and flushed gilts received an additional one percent of their body weight as glucose. Glucose fed gilts shed 2.1 more ova than the control gilts. In a third study gilts that were fed additional glucose (one percent of body weight) shed 0.8 more ova, those fed lard (0.44 percent of body weight) 1.9 more ova and those fed lard (0.66 percent of body weight) 4.1 more ova than unflushed gilts.

McGillivray _et al_. (1962) started ten days prior to mating and imposed the following treatments on one year old gilts; no feed, normal intake of 4 pounds (16 percent corn-soybean meal diet) per head per day, 4 pounds of same diet plus 4 pounds of glucose per head daily. At slaughter 25 to 30 days after mating, ovulation sites, number of total embryos and number of viable embryos and weight gain all increased when the energy level of the diet was increased. Additional gilts on the same treatment were given 6α methyl 17α hydroxyprogesterone acetate (HPA-200 milligrams per head daily). The most consistent effect of HPA was a decrease in ovarian weight. For all trials the conception rate (presence of embryos) was 58, 81 and 64 percent for gilts on starvation, normal intake and high energy intake, respectively. In a subsequent project, McGillivray _et al_. (1963) using the same diets fed to year old gilts found that when the normal energy diet was fed both prior to and after breeding the average number of ovulation sites and the conception rate was 15.2 and 83.3 percent, respectively; for those fed the high energy to breeding followed by the normal level, 14.7 and 88.7 percent, and for those fed normal prior to breeding and then the high energy intake 16.1 and 86 percent, respectively. No differences were observed in the total and viable embryos and conception rates based on post-breeding treatments of normal and high energy intake.

Stothers (1962) fed gilts an average of 5.9 pounds per head per day during gestation, and found that they made significantly smaller gains than those fed an average of about 7.25 pounds per head per day. No significant differences between treatments were observed on the number of pigs born, the number of stillbirths or the average pig birth weights.

Pickett and Beeson (1962) found that gilts fed 4 pounds per head per day of a reduced energy ration during gestation gained less per day and farrowed smaller pigs than those fed 5 pounds, 0.87 and 2.5 versus 1.10 and 2.7 pounds, respectively. However, gilts on the reduced energy intake weaned an average of 8.2 pigs averaging 34 pounds, while gilts on a higher energy level during gestation weaned 7.8 pigs weighing an average of 32 pounds.

Day et al. (1963) failed to induce a statistically significant improvement in embryonic survival by the administration of 100 milligrams of progesterone caproate and 50 micrograms of estradiol benzoate per 100 pounds of body weight on the eleventh day after mating. However, a trend toward increased litter size was observed. In a second experiment the percentage of corpora lutea represented by living embryos was not increased in gilts and sows implanted with progesterone caproate and estradiol benzoate on the seventh day of pregnancy.

Gilts and sows fed 3 pounds of feed per head daily (4698 met kilocalories/day) immediately following breeding gained significantly less during gestation than did gilts or sows receiving 6 pounds per head daily (9396 kilocalories/day) according to Clawson _et al_. (1963). The gain, however, during lactation was greater for those that had received only 3 pounds per head per day during gestation. In trial one, gilts fed the low energy level farrowed significantly more live pigs while in the second trial gilts fed the high energy level farrowed more pigs and the litters were significantly heavier at birth. In trial 3 (gilts) and trial 4 (sows) there were no significant differences in live pigs farrowed between feeding levels. In the four trials, heavier pigs were farrowed by gilts receiving the higher energy intake. Level of energy during gestation did not significantly influence pig survival, number of pigs weaned or litter weight at weaning. Also, the level of protein (0.3 or 1.2 pounds per head per day) during gestation did not significantly affect reproductive performance as measured by number of pigs farrowed, birth weight, pig survival or litter weight at weaning.

Meade _et al_. (1963) fed gilts 5 pounds per head daily of an 18 percent protein ration throughout gestation and an additional one pound of ground yellow corn per head daily during the last 30 days of this period. The gilts gained 0.17 pounds less daily than gilts fed 6 pounds per head daily of a 15 percent protein ration. The number of live pigs farrowed and birth weights were about the same for both groups.

Thrasher (1963) found that sows self-fed a high fiber ration during gestation gained less per day and farrowed more live pigs that were lighter at birth than did sows that were fed 5 pounds of a standard ration daily, 0.78, 11.8, 2.6 versus 1.01, 9.1 and 3.1, respectively. In a second trial the number of live pigs per litter was higher for the sows fed 5 pounds daily compared to self-fed sows, 10.3 versus 8.6, however, the difference was not significant.

Salmon-Legagneur (1962) fed a ten percent protein ration at 3 different levels during gestation. One group received a ration that furnished 15 percent above the estimated maintenance requirements throughout gestation. Another group was fed a maintenance ration for the first half of pregnancy and then 30 percent above maintenance, and the third received 30 percent above maintenance for the first half and a maintenance level thereafter. A fourth group was not mated and received 15 percent above maintenance until the others farrowed. There was little difference between groups of pregnant sows in weight gain either with or without the products of conception, and all gained more than the non-pregnant sows. The fetuses of the group given the high plane during the second half were somewhat heavier than in the other groups, and those fed the higher plane during the first half laid down more fat during that period, and on the average over the whole time, than did the other pregnant groups. The non-pregnant sows laid down the most fat. There were no significant differences between pregnant groups in numbers or weight of young born or weaned or the growth rate of the pigs. Loss of weight by the sows during lactation was similar in all groups. In another experiment Salmon-Legagneur (1963) fed two levels of energy (8,900 and 13,700 calories/day) and two levels of protein (68 grams and 44 grams/day) to sows during gestation. The weight and number of pigs at parturition were little affected by the variations in the level of protein or energy level of the ration. However, if the rate of energy increases rapidly, it appears to be responsible for a slight increase in embryonic mortality. No effect on lactation was observed.

Rigor *et al*. (1963) studied the effects of small amounts of exogenous estradiol-17-β on early embryo survival and on corpus luteum formation and maintenance in gilts fed rations of high and low fiber content. Embryo survival was not affected adversely by *ad libitum* feeding of the low fiber ration. The gilts on the low-fiber ration averaged 59 percent embryo survival and those on the high-fiber 50 percent, however, this difference was not significant. This difference was in the opposite direction from what has been reported from most experimental trials.

Increasing the level of feed from 4 to 6 pounds per day during the last month of gestation did not increase the litter size or the birth weights over gilts fed four pounds of feed per day throughout pregnancy according to Waite _et al_. (1964).

Chow (1964) in a study with rats indicates that the body weight of the pups after birth, even when allowed an adequate diet _ad libitum_, reflects the dietary history of the dam during gestation and lactation. These studies minimize genetic factors since the parents were the same in successive cycles. The same female will produce smaller-size progeny if her diet is restricted during a second pregnancy, and the progeny of a third pregnancy can be larger (as large as the first) if the animal is allowed feed _ad libitum_ again. From the data in this study, the food consumption of the dam is demonstrated to be an important factor in determining the body weight of the progeny.

Bowland (1964a, 1964b) fed gilts from an average initial weight of 44 pounds until the end of the second lactation. Sixty sows (littermates from 12 litters) were fed two levels and two sources of energy and two levels of protein in five ration groups. Sows fed rations formulated to meet U.S. National Research Council nutrient requirements, and allowed no access to pasture, performed similarly during two gestation and lactation cycles when they were allowed feed _ad libitum_ during growth and 6 pounds per day during gestation, or when they were restricted in feed intake by 20 percent during growth and 8 percent during gestation. During lactation all sows were fed at an energy level based on the number of suckling pigs. Between lots (rations) there was a non-significant negative correlation between gain in weight during gestation and number of pigs born alive (r = -0.73) and positive correlations between total birth weight and total weaning weight (r = 0.83), and gain in weight during first and second gestations (r = 0.85). The most important of these is the high negative relationship of sow gain during gestation with the number of pigs born alive. Birth weight was negatively influenced by gestation gain to a lesser extent. Within lots gain during gestation had a limited effect on the number of pigs born alive (r = 0.24), but was more closely associated with total birth weight of pigs (r = 0.54). The results indicate that, when the effects of feeding levels are removed, reasonably high gestation gains are desirable in relation to litter birth weights. This suggests that the gestation weight gains of individual sows tend to repeat and that level of feeding has little control over birth weights. Between lots (rations) number of pigs born alive was negatively influenced by gestation weight gains, and this was presumably associated with feeding methods. Therefore, within limits feeding methods should be used that produce low gestation weight gains.

Frobish (1964) started one week prior to the start of mating and fed various rations comparing two energy levels

(6,000 and 12,000 metabolizable calories/sow/day) and two protein levels (0.4 and 0.8 pounds/sow/day). These rations were fed throughout the gestation period for three successive reproductive cycles. The higher feeding level showed no advantage in number of pigs farrowed or weaned or the birth weight or weaning weight of the pigs. Sow gain from the start of each reproductive cycle until weaning was greater for the sows fed the higher energy intake. A greater number of the sows on the higher feeding level failed to complete three reproductive cycles.

Rippel et al. (1965) in a study with 155 animals evaluated the effect of level and source of protein fed during the last half of pregnancy on the reproductive performance of swine. Neither level nor the source of protein influenced litter size, number of live pigs farrowed, birth weight of live pigs or pig livability.

Becker et al. (1965) found no difference in the number of total and live pigs farrowed, birth weight and the number and weight of pigs weaned at 2 weeks when sows or gilts were fed 4 pounds per head per day in dry lot or 4, 3 or 2 pounds per day on pasture. Gain of the animals during pregnancy varied directly with the amount of feed fed on pasture, and at 4 pounds of feed per head daily sows and gilts on pasture outgained those in dry lot. Three pounds of feed per head daily on pasture provided a gain of sows and gilts during pregnancy equal to 4 pounds per head daily in dry lot.

Schultz *et al*. (1965) hand-fed gilts 1.82 kilograms per day of a corn-soybean ration (14 percent protein) for a duration of three estrus cycles prior to treatment. In trial 1, gilts fed a high level of 2.72 kilograms per day for three weeks prior to estrus until slaughter at 25 days after fertile mating had a significantly greater percent embryonic survival than did those gilts fed 1.82 kilograms per day, 83 versus 70 percent, respectively. In trial 2, gilts fed 3.64 kilograms per day for three weeks prior to fertile mating exhibited significantly more corpora lutea than those fed 1.82 kilograms.

Repeatability of litter traits

Lush and Molln (1942) describe repeatability as a measure of the fraction of the difference found between two sows in one season which is most likely to be found between them in the future. For example, let repeatability of number of pigs farrowed be equal to 0.147. Then, if sows which averaged one pig per litter more than the average of all sows, their second litters would be expected to average 0.147 pigs more than if no selection had been practiced.

Repeatability coefficients were computed by Lush and Molln (1942) from data from 11 different experiment stations. The coefficients for the number of pigs farrowed ranged from -0.03 to 0.17, with an average computed from the means of the pooled sum of squares of 0.13. For the number of pigs weaned the range was from -0.01 to 0.24 with an average of 0.13. The weaning weight of the litter from data from six stations ranged from -0.07 to 0.37 with an average of 0.12.

Olbrycht (1943) studied the total life performance of 156 sows that had farrowed 10 litters. The number of pigs farrowed was found to increase up to the fifth litter, but if the first litter was delayed 160 days, then the peak number farrowed was in the fourth litter. Their data indicate that the age at first breeding affects the size of the first litter and maximum litter size is a function of age rather than number of litters. The data also suggests that prolific sows probably rear a lower percentage of their total pigs. They predicted that 12.6 pigs farrowed per litter is the optimum. An increase by one pig born was observed to increase the number reared in that litter by 0.44. The regression coefficient for number born in the first litter on total number born in 10 litters was 0.097. These authors concluded that judging of sows from their first litter performance is of very appreciable advantage, and information on breeding efficiency can be obtained from the first litter. However, pooling the first two litter performances gives more accurate results than judging based only on the first litter.

EXPERIMENTAL

General Objectives

This experiment was conducted to study the effects of two levels of feed intake during two periods of the reproductive cycle at the time of mating and during the last third of gestation on the reproductive performance of swine.

General Experimental Methods

The experiment reported herein is on file in the Swine Nutrition Section of the Animal Science Department, Iowa State University, Ames, Iowa. Three trials were conducted, and are numbered as Swine Experiments 6317, 6317A and 6317B.

The following materials and procedures were similar for the three trials. All animals were obtained from the swine nutrition farm breeding herd. The sows and gilts used in this experiment were of Yorkshire, Landrace, and Yorkshire x Landrace breeding. As young pigs, the sows and gilts were vaccinated with modified cholera virus and anti-serum and erysipelas bacterin. The gilts were re-vaccinated with modified cholera virus when they reached approximately eight months of age and at least one week prior to mating. Prior to mating, all animals were blood tested for Brucellosis and Leptospirosis and vaccinated with Leptospirosis bacterin. All animals were wormed with piperazine prior to the start of each trial, and they were periodically sprayed with toxaphene to control mange.

The experiment consisted of a possible 192 litters of which 176 litters were obtained. Sows maintained through three successive reproductive cycles accounted for 105 of these litters. Each trial consisted of 64 animals that were randomly allotted from littermate or weight and age outcome groups to a completely randomized design with a 2 x 2 factorial arrangement of experimental treatments. There were four pens with four replications of each treatment in each pen. Each sow was maintained on the same treatment throughout the three trials, the only exception being the gilts used to replace those which failed to reproduce in trials one and two. Animals that failed to farrow in the previous trial were replaced along with three other animals so as to replace a complete set of 4 animals, equally affecting the four experimental treatments. Sows that did not conceive were sacrificed, and the reproductive tracts removed and examined for abnormalities.

All animals were maintained in dry lot and pen mated to littermate Poland China boars with one boar being assigned to each group of 16 sows. The animals were individually fed once a day during pregestation and gestation. Automatic waterers were provided, and corrugated steel type buildings, open on one end were used as shelters. The sows were brought into the farrowing unit on approximately the 109th day of gestation.

Before entering the farrowing crate, the animals were weighed, thoroughly washed and sprayed with toxaphene. They remained in the farrowing crates from the time they were brought into the farrowing unit until pigs were weaned at two weeks of age. After farrowing, the sows were brought up to a full feed by hand-feeding twice a day.

Within 20 hours after birth, each pig was weighed, ear marked, eye teeth clipped, and given an injection of 100 milligrams of elemental iron in the form of iron dextran for the prevention of anemia. All pigs weighing less than 1.8 pounds were sacrificed. The male pigs were castrated at approximately five days of age. Two weeks after farrowing, weaning weights were obtained for both the sow and pigs.

The composition and calculated analysis of the ration used is presented in Tables 1 and 2. The four ration treatments are denoted as follows: high-high level (HH), high-low (HL), low-high (LH) and low-low (LL). The 16 sows within each of the four pens were allotted to one of the four treatments. Eight of the animals in each pen were on the high level and eight were on the low level at the time of mating. Also, eight of the sows in each pen were on the high level during the last one-third of gestation and eight were on the low level. This design allowed four replications of each treatment within each pen, and a total of 16 replications of each treatment per trial.

The treatments were imposed for 2 weeks prior and 3 weeks following the start of mating and then again from the 84th day after the start of mating until farrowing. From the fourth through the twelfth week all animals were fed the low level of feed intake. All animals were full-hand-fed the same ration during lactation.

The data collected from this experiment were statistically analyzed by methods described by Snedecor (1956).

Experiment 6317

Experimental Sixty-four gilts were used in the first trial conducted between May, 1963, and December, 1963. Two weeks prior and three weeks following the start of mating, animals on the high level received six pounds of ration per head per day, and those on the low level received four pounds of ration per head per day. From the 4th through the 12th week all animals received four pounds per head per day. From the 12th week or the 84th day after the start of mating the sows on the high level were fed 6 pounds per head per day and those on the low level 4 pounds per head per day. During the winter months straw bedding was provided as needed. After weaning all sows were individually fed five pounds per head per day until the start of the next trial.

Results The summaries and analysis of variance plans and observed mean squares are presented in Tables 5 through 20 and Figures 1 through 5.

The sows receiving the high level of feed intake during the last third of gestation gained significantly more ($P \leq 0.01$)

Figure 1. Experiments 6317, 6317A, 6317B - effect of level of feed intake on number of pigs farrowed alive and dead

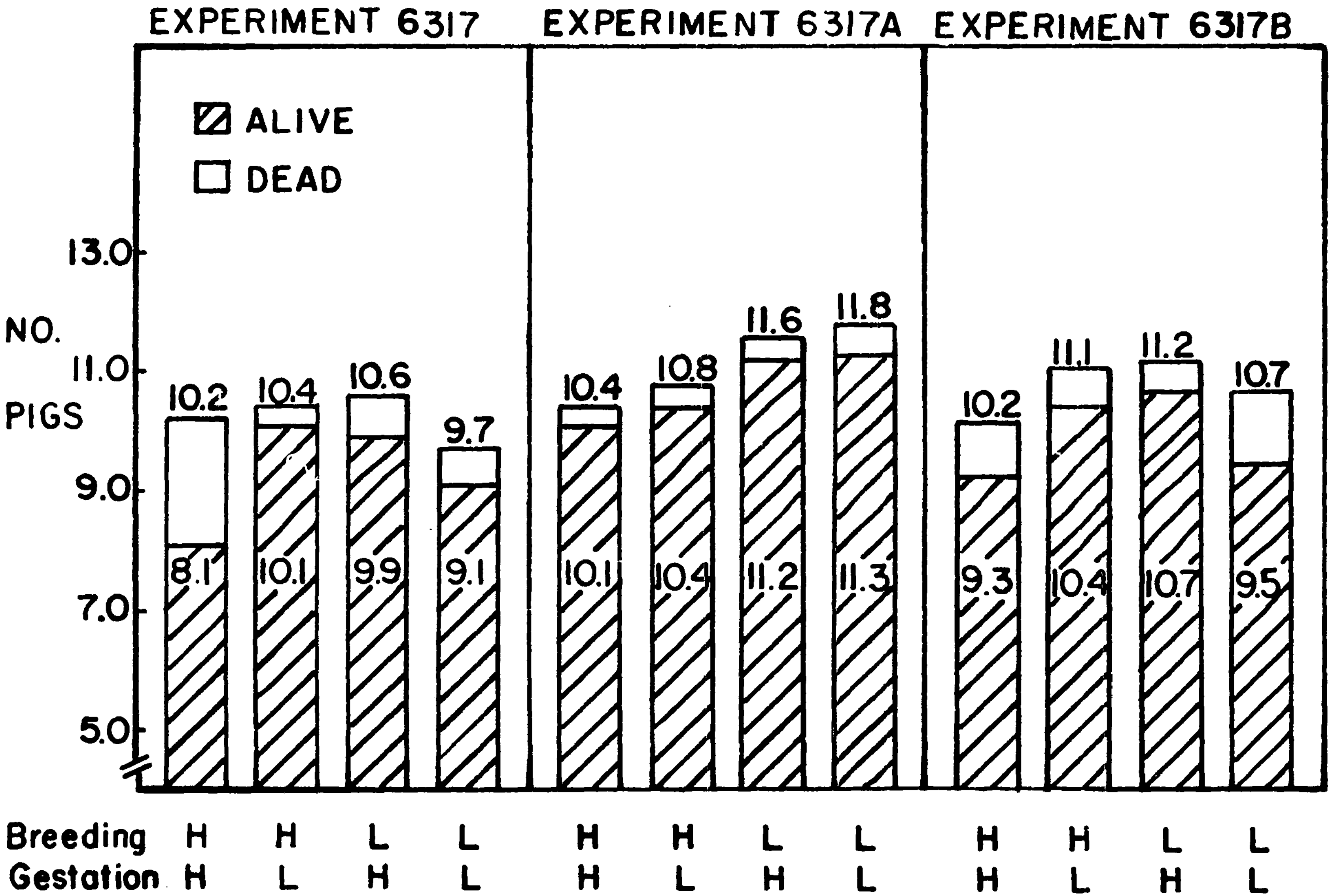

EXPERIMENT 6317
EXPERIMENT 6317A
EXPERIMENT 6317B
ALIVE
DEAD
NO. PIGS
13.0
11.0
9.0
7.0
5.0
10.2
8.1
10.4
10.1
10.6
9.9
9.7
9.1
10.4
10.1
10.8
10.4
11.6
11.2
11.8
11.3
10.2
9.3
11.1
10.4
11.2
10.7
10.7
9.5
Breeding H H L L H H L L H H L L
Gestation H L H L H L H L H L H L

Figure 2. Experiments 6317, 6317A, 6317B - effect of level of feed intake on the birth weight of live pigs

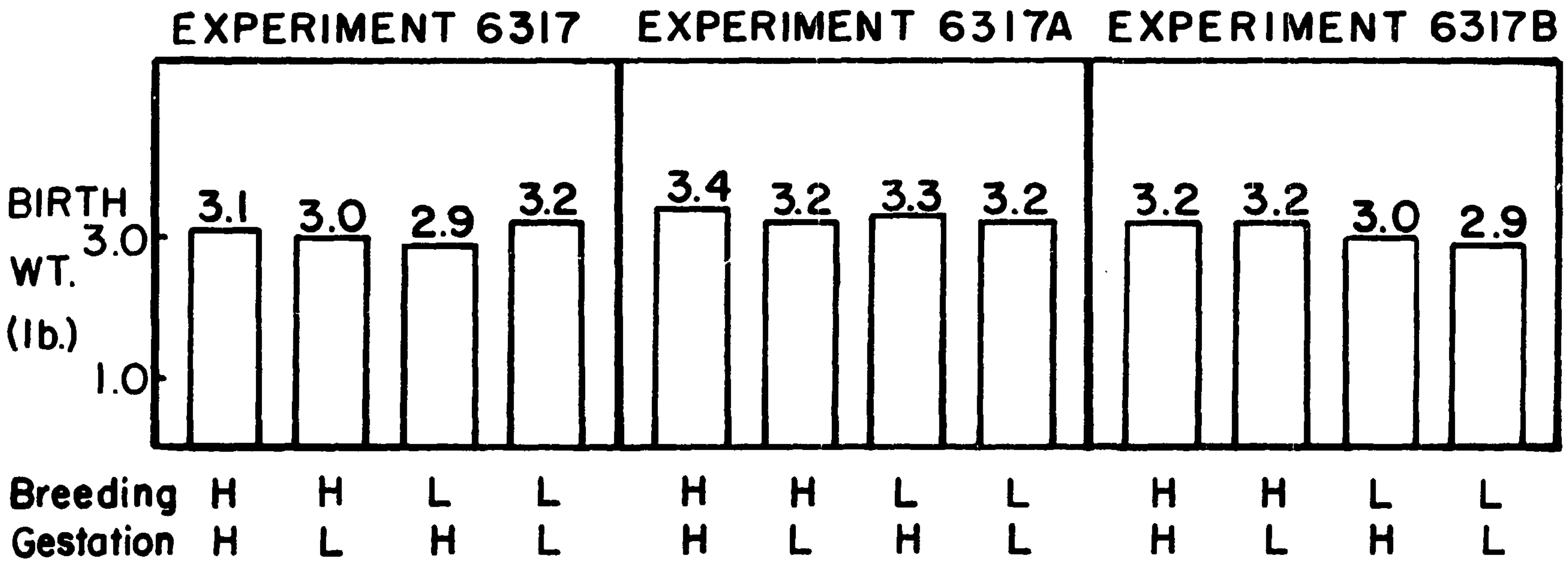

EXPERIMENT 6317
EXPERIMENT 6317A
EXPERIMENT 6317B
BIRTH WT. (lb.)
3.0
1.0
3.1
3.0
2.9
3.2
3.4
3.2
3.3
3.2
3.2
3.2
3.0
2.9
Breeding H H L L H H L L H H L L
Gestation H L H L H L H L H L H L

Figure 3. Experiments 6317, 6317A, 6317B - effect of level of feed intake on number of pigs weaned

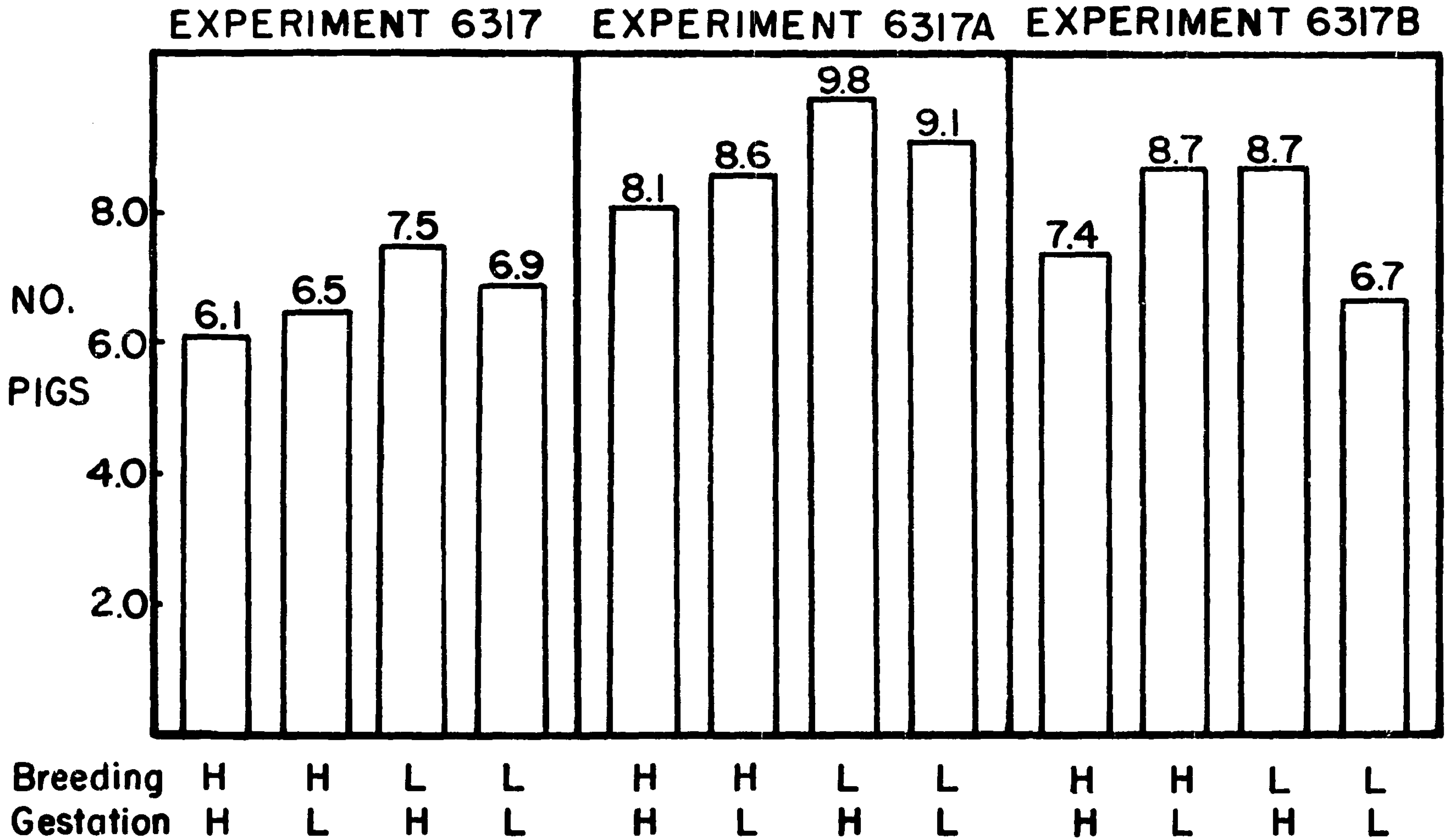

EXPERIMENT 6317
EXPERIMENT 6317A
EXPERIMENT 6317B
NO. PIGS
8.0
6.0
4.0
2.0
6.1
6.5
7.5
6.9
8.1
8.6
9.8
9.1
7.4
8.7
8.7
6.7
Breeding H H L L H H L L H H L L
Gestation H L H L H L H L H L H L

Figure 4. Experiments 6317, 6317A, 6317B - effect of level of feed intake on pig gain from birth to weaning

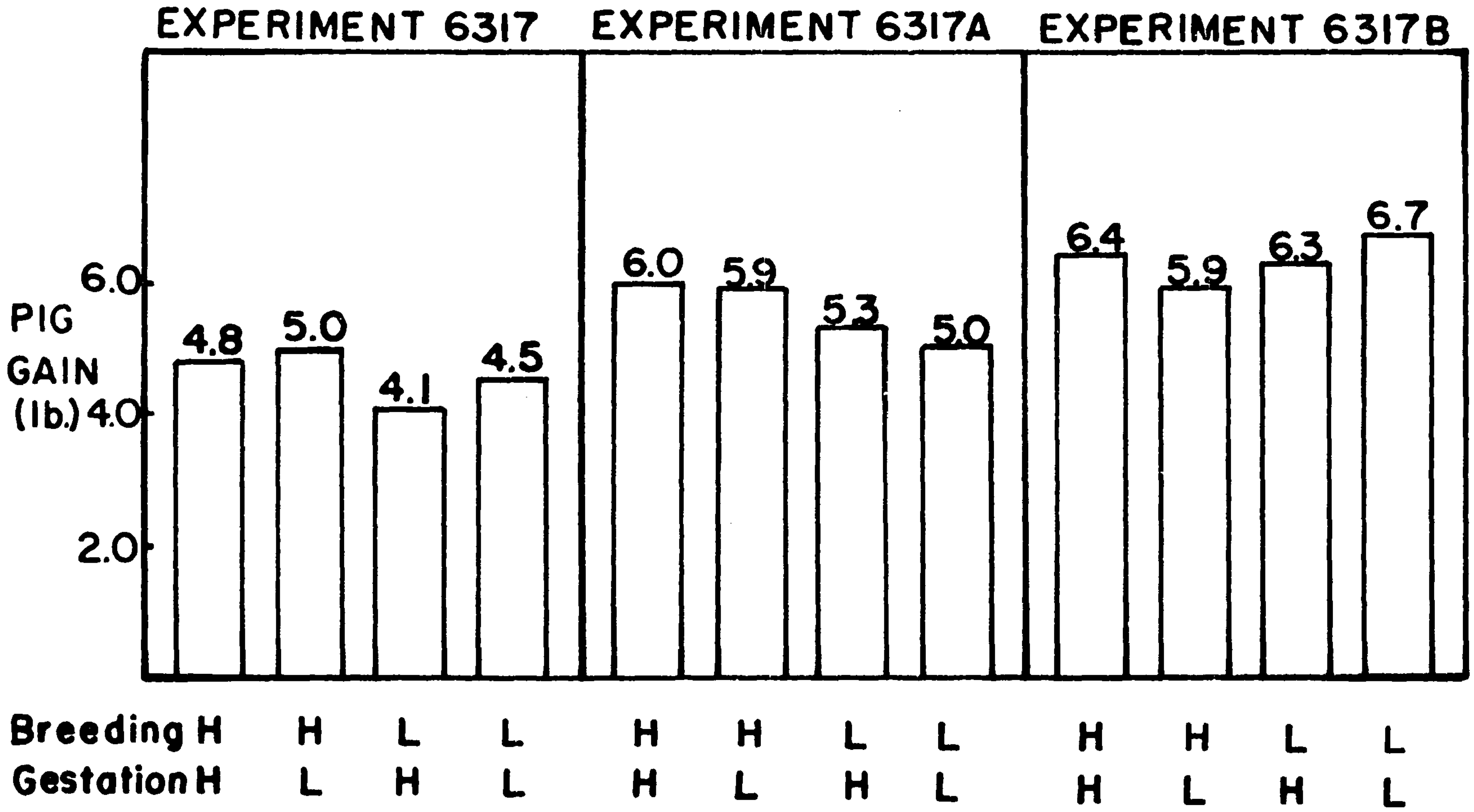
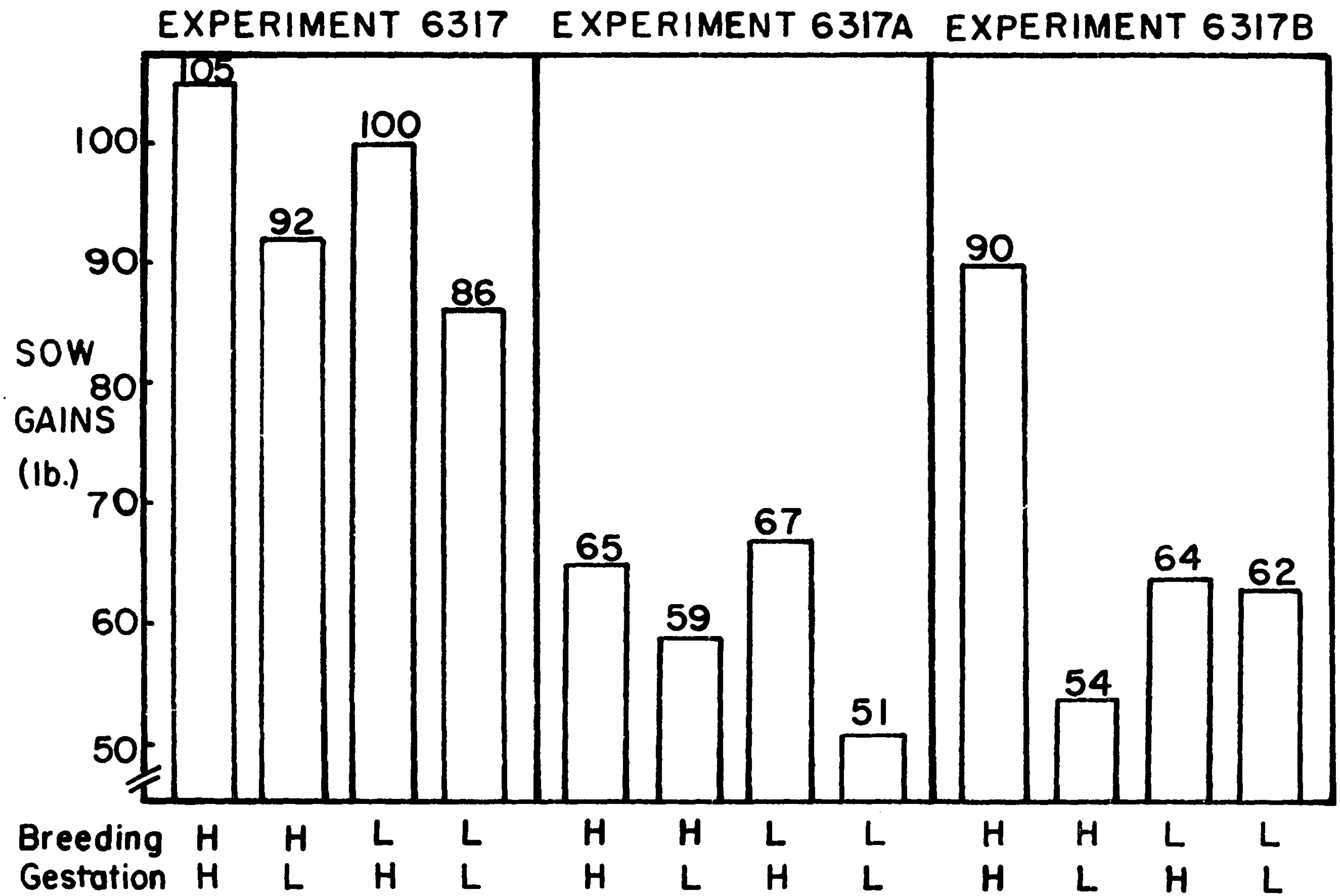

EXPERIMENT 6317
EXPERIMENT 6317A
EXPERIMENT 6317B
PIG GAIN (lb.)
6.0
4.0
2.0
4.8
5.0
4.1
4.5
6.0
5.9
5.3
5.0
6.4
5.9
6.3
6.7
Breeding H H L L H H L L H H L L
Gestation H L H L H L H L H L H L

Figure 5. Experiments 6317, 6317A, 6317B - effect of level of feed intake on sow weight change from initial to weaning


EXPERIMENT 6317
EXPERIMENT 6317A
EXPERIMENT 6317B
SOW GAINS (lb.)
100
90
80
70
60
50
105
92
100
86
65
59
67
51
90
54
64
62
Breeding H H L L H H L L H H L L
Gestation H L H L H L H L H L H L

from initial to weaning than those fed the low level, 103 versus 89 pounds, respectively.

No significant differences were observed on the average birth weight of pigs, the number of pigs farrowed alive, the number of pigs weaned, and the average gain from birth to weaning, and no interactions were present between the treatments.

Those sows receiving the high level of feed intake at breeding time and also during the last one-third of gestation tended to have a higher percent of the pigs born dead.

Though a pen mating system was used in these experiments an attempt was made to evaluate conception rate at first estrus after the start of mating of those sows that farrowed. The maximum number of days from the start of breeding to farrowing was considered to be 135 days for a sow to have conceived the first estrus. In this trial no differences in conception rate were observed between treatments. Fifteen gilts apparently failed to conceive at first estrus. Two of these were on the HH treatment, 3 on the HL, 5 each on the LH and LL treatments.

Two sows died while farrowing in this trial, one on the HH and one on the HL treatments. Five sows failed to farrow. One sow on the HH was apparently normal. Three sows on the HL were apparently normal and two of these were pregnant when sacrificed. One sow on the LL treatment had an infection in the reproductive tract.

Experiment 6317A

Experimental The second trial was conducted between November, 1963 and June, 1964. The same sows used in the first trial were maintained on the same treatment in the second trial, except that the high level of feeding was 7 pounds and the low level was 5 pounds. Gilts were used in the experiment to replace those sows not farrowing in the first trial. Bedding was provided as needed during the winter months. After weaning all sows were individually fed 4 pounds per head daily until the start of trial 3.

Results The summaries and analysis of variance plans and observed mean squares for Experiment 6317A are shown in Tables 21 through 36 and Figures 1 through 5.

In this trial, sows on the LH and LL treatments farrowed significantly more ($P \leq 0.05$) live pigs than did sows on the HH and HL treatments, 11.2 versus 10.2 pigs, respectively.

Again in this trial, 6317A sows on the HH and LH gained significantly more ($P \leq 0.05$) from initial to weaning, than did sows on the HL and LL treatments, 66 pounds versus 55 pounds, respectively.

No significant differences were observed on the average birth weight of live pigs, number of pigs weaned or pig gain from birth to weaning. No interactions were observed between treatments.

The number of pigs farrowed followed a similar trend as the number farrowed alive. High-high and HL sows farrowed fewer total pigs than the LH or LL groups, 10.6 versus 11.7 pigs, respectively. No differences were observed in conception rate. One sow on the LL treatment died while farrowing. Three sows on the LH and one sow on the HL treatment failed to farrow. Reproductive tracts from these sows were apparently normal.

Experiment 6317B

Experimental The third trial was conducted between May, 1964 and December, 1964. The animals were maintained on the same treatments as in the first two trials, except that gilts were added to the experiment to replace those sows not farrowing in the second trial. The high level of feeding in this trial was 6 pounds and the low level was 4 pounds of feed per head per day.

Results The summaries and analysis of variance plans and observed mean squares are shown in Tables 37 through 52 and in Figures 1 through 5.

There were no significant differences between treatments observed on the number of pigs farrowed alive, and average pig gain from birth to weaning. Sows fed the high level of feed at mating farrowed litters with a significantly greater ($P \leq 0.05$) average birth weight than did those fed the low level of feed intake, 3.2 pounds versus 2.9 pounds, respectively.

A significant ($P \leq 0.05$) interaction was observed on number of pigs weaned. Sows fed the HL weaned more pigs than those on the HH treatment (8.7 versus 7.4 pigs), however, sows on the LH weaned more pigs than those on the LL treatment (8.7 versus 6.7).

A highly significant ($P \leq 0.01$) interaction was observed on sow gain from initial to weaning. Sows on the HH gained 90 pounds, HL - 54, LH - 64, LL - 62, thus the difference in gain for the HH and HL treatments was much greater than it was for the LH and LL treatments resulting in the interaction.

Only small differences were observed between treatments on number of pigs farrowed, the average percent of pigs born dead and average days from breeding to farrowing. However, the percent of the live pigs weaned for LL fed sows was 66 percent compared to an average of 83 percent for the other three treatments.

A total of eleven sows apparently failed to conceive the first estrus. Four of these were on the HH ration, 3 on the HL, 2 on LH and 2 on the LL diet.

One sow on the LH died while farrowing, two sows on the HH treatment failed to farrow. One of these had cystic follicles and the other was normal with 11 normal embryos and 2 degenerating embryos.

Experiment 6317, 6317A, 6317B

The summaries and analysis of variance for the three trials 6317, 6317A and 6317B are presented in Tables 53 through 69 and the main treatment effects are presented in

Figures 6 and 7.

In trial 6317 and 6317B, there were no significant differences in the number of pigs farrowed alive, however, in trial 6317A, sows on the low level of feed intake at time of mating farrowed a significantly greater number of pigs than did sows on the high level. In the combined analysis of the three trials, a significant ($P \leq 0.05$) interaction was observed. Sows on the HL ration farrowed more live pigs than HH sows. However, sows on the LH ration farrowed more live pigs than those on the LL treated sows resulting in the interaction.

No significant differences in the average birth weight of live pigs was observed in trial 6317 or 6317A. In trial 6317B and also in the combined analysis, the birth weight of pigs from sows fed the high level of feed intake at mating time had a significantly greater ($P \leq 0.05$) average birth weight than those fed the low level of feed intake.

A significant interaction ($P \leq 0.05$) was observed on the number of pigs weaned in Experiment 6317B and in the combined analysis. This interaction was similar to the one observed on number of pigs farrowed alive. No significant differences or interactions were observed in 6317 and 6317A.

No significant differences were observed between treatments in the individual trials or combined analysis on the average pig gain from birth to weaning.

In trial 6317 and 6317A the sows on the high level during the last one-third of gestation gained significantly more (P

Figure 6. Experiments 6317, 6317A, 6317B - main effects of level of feed intake on number of pigs farrowed, number farrowed alive, and the number weaned

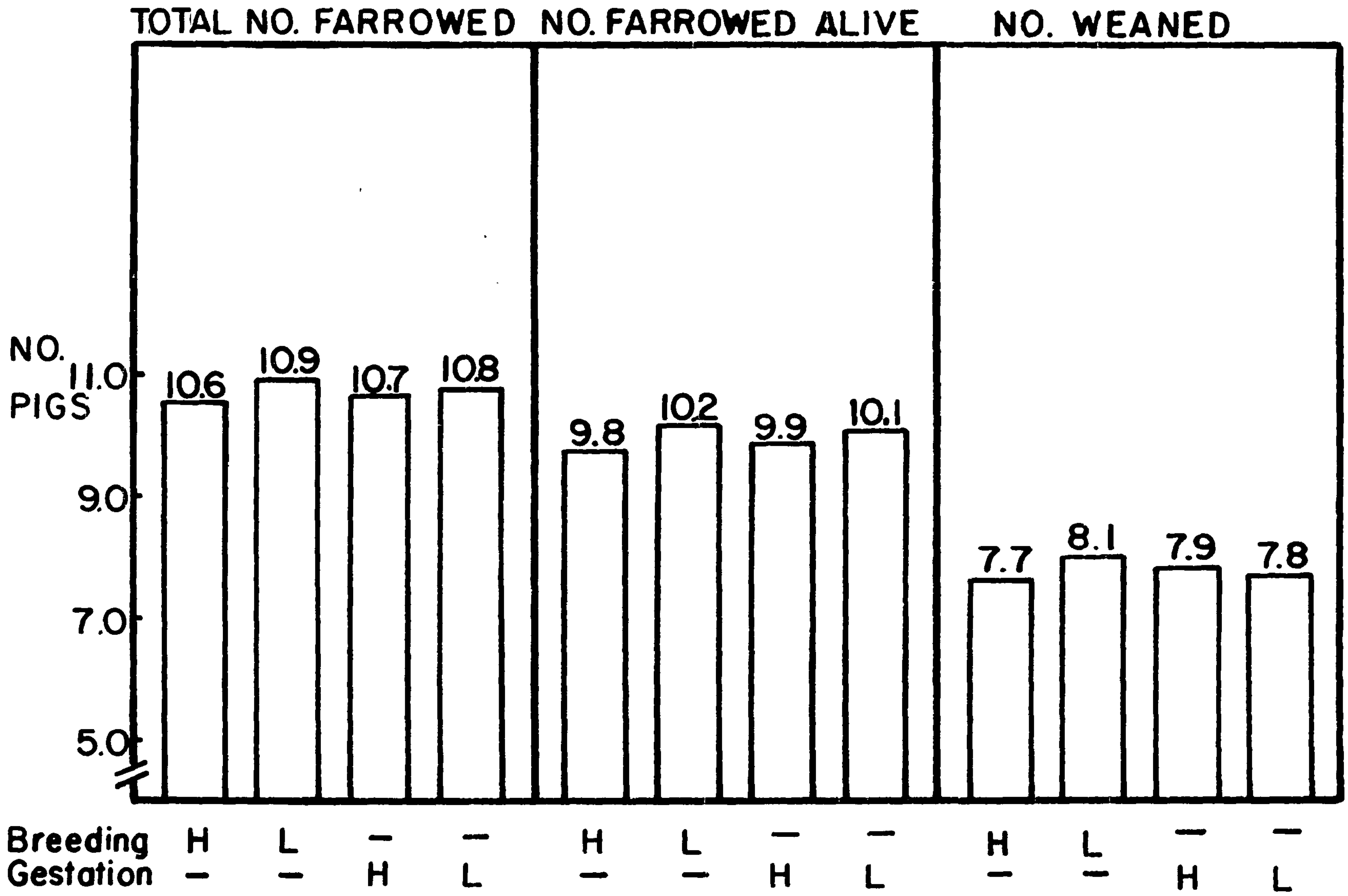
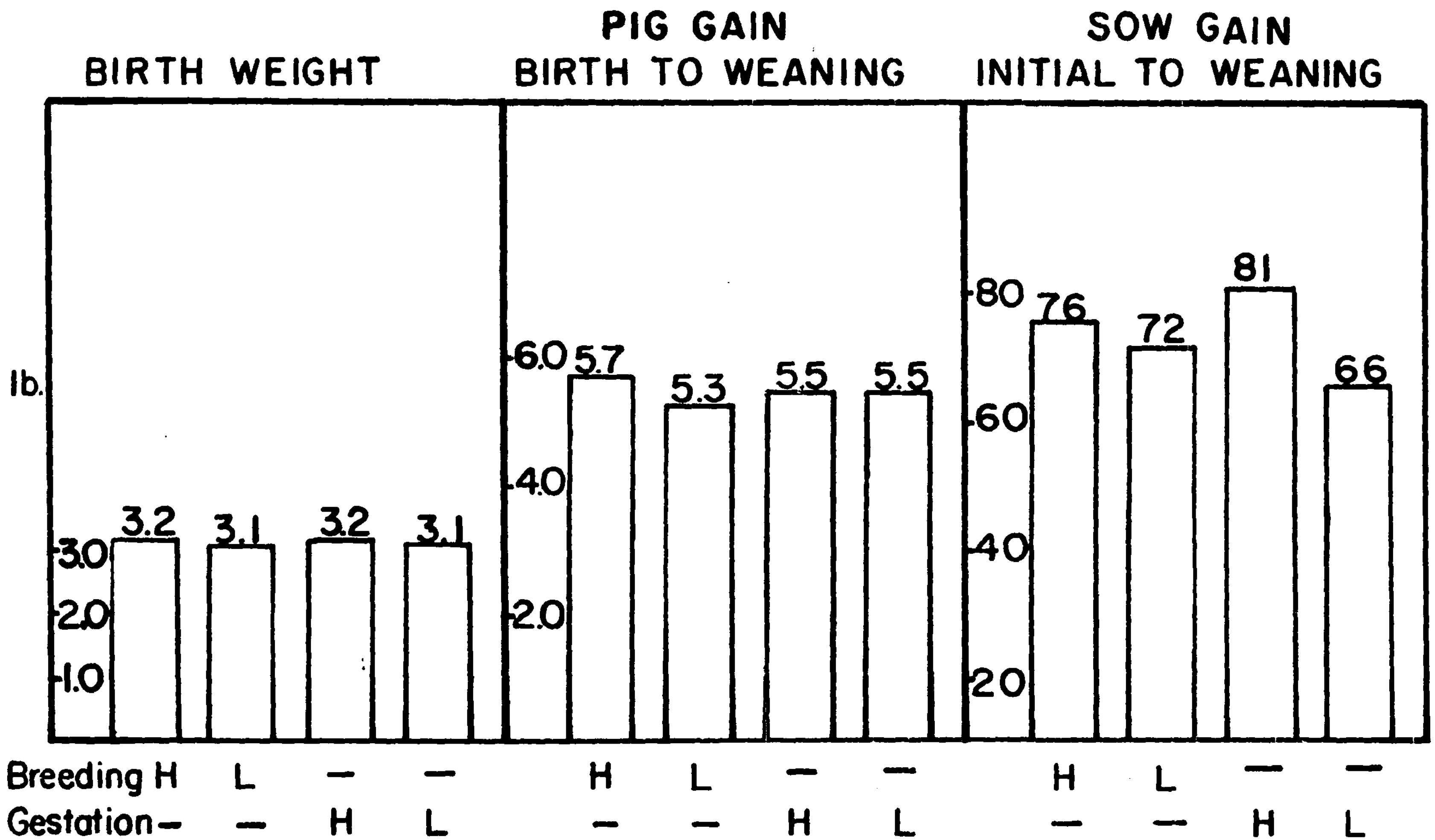

TOTAL NO. FARROWED
NO. FARROWED ALIVE
NO. WEANED
NO. PIGS
11.0
9.0
7.0
5.0
10.6
10.9
10.7
10.8
9.8
10.2
9.9
10.1
7.7
8.1
7.9
7.8
Breeding H L — — H L — — H L — —
Gestation — — H L — — H L — — H L

Figure 7. Experiments 6317, 6317A, 6317B - main effects of level of feed intake on the average birth weight of live pigs, average pig gain from birth to weaning, and sow gain from initial to weaning


BIRTH WEIGHT
PIG GAIN BIRTH TO WEANING
SOW GAIN INITIAL TO WEANING
lb.
3.2
3.1
3.2
3.1
3.0
2.0
1.0
6.0
4.0
2.0
5.7
5.3
5.5
5.5
80
60
40
20
76
72
81
66
Breeding H L — —
Gestation — — H L
H L — —
— — H L
H L — —
— — H L

≤0.05) from initial to weaning than did sows on the low level. In trial 6317B, a highly significant interaction was observed. When the three trials were combined a greater gain ($P \leq 0.01$) was observed in those sows fed the high level during the last third of gestation compared to those fed the low level.

A slightly higher percent of pigs were born dead (Table 64) in litters from sows on the HH compared to the others. Only small differences were observed in percent live pigs farrowed that were weaned, number of pigs farrowed alive and dead, and average number of days from the start of breeding to farrowing.

The average total feed consumption from two weeks prior to the start of mating until weaning was the highest for the HH fed sows, about the same for the HL and LH groups and lowest for the LL sows. The pounds of feed required per pig weaned was higher for the HH treated sows than for the other three treatments.

Experiment 6435

Up to the present time only limited data has been available from the individual feeding of sows through the breeding and gestation period. This method of feeding may help reduce the large experimental error inherent in reproduction studies, and improve the reliability of the conclusions drawn from such studies. The individual feeding of the pregnant sow offers a definite advantage experimentally because it maximizes from a statistical point of view the information from a given sow. There is also the possibility that the method of feeding affects the correlation of reproductive performance among reproductive cycles.

The purpose of this study was to compare the repeatability of reproductive performance between gilts and sows fed individually throughout the reproductive cycle and those fed in a group.

Experimental The data reported is on file in the Swine Nutrition Section of the Animal Science Department, Iowa State University, Ames, Iowa, and is numbered as Swine Nutrition Experiment 6435. Both the individually-fed animals and the group-fed animals were handled as described under the general experimental methods, with the difference being in the method of feeding. Data was obtained from Swine Nutrition Experiments 1128, 1171, and 6317 in which sows were individually-fed and maintained on the same treatments within experiments throughout three reproductive cycles. Data for the group-fed sows were obtained from the swine nutrition farm breeding herd records. The sows and gilts used in this study were of Yorkshire x Landrace and Landrace breeding. These sows were fed a ration that was not identical to the various experimental diets fed in Experiments 1128, 1171, 6317.

The total number of pigs farrowed, number of pigs farrowed alive, number of pigs weaned and weaning weight were the four criteria examined in this study. The data was statistically analyzed by methods described by Snedecor (1956).

Results The summaries and analysis of variance plans and observed mean squares are presented in Tables 70 through 83.

The repeatability coefficients for the individually-fed sows were higher than those for the group-fed sows for total number of pigs farrowed, number of pigs farrowed alive and for weaning weight adjusted for the number of pigs weaned, 0.33, 0.19, and 0.25 versus 0.23, 0.16, and -0.06, respectively (Table 70). However, for number of pigs weaned the reverse was true in that the repeatability coefficient for the group-fed sows was higher (0.14) than it was for the individually-fed sows (0.07). From the combined data of both groups, the repeatability coefficients for total pigs farrowed, pigs farrowed alive, number of pigs weaned and weaning weight adjusted for number of pigs weaned were 0.29, 0.18, 0.10 and 0.13, respectively. The regression coefficients (Table 71) are for litters two and three combined on litter one.

The regression coefficients for repeatability of the litter traits of sows with Yorkshire x Landrace breeding for total pigs farrowed, the number of pigs farrowed alive and number of pigs weaned were 0.90, 0.53, and 0.38 versus 0.51, 0.37, and 0.16 for the individual and group-fed animals, respectively. The same regression values for the Landrace breed were 0.26, 0.70, 0.17 versus 0.09, 0.06, and 0.5 for the individual versus group-fed sows, respectively.

DISCUSSION

Effect of Feed Level on Number of Pigs Farrowed Alive

In Experiments 6317 and 6317B reported herein, no significant differences were observed between treatments on the number of pigs farrowed alive. However, in Experiment 6317A, those sows fed the lower level of feed intake at the time of mating farrowed significantly more pigs (Table 21, 22) than did those sows on the high level of feed intake. In the combined analysis of the three trials a significant interaction was observed. Observations on the number of pigs farrowed alive and dead followed a similar trend.

Marshall and Potts (1921) in early studies observed an increase of 18.1 percent in the number of lambs born as a result of flushing. With sheep fewer ova are shed in comparison to the sow, and it is doubtful that the practice of flushing is as important in swine as it is in sheep.

The practice of feeding gilts on a high plane to increase ovulation rate is supported in studies by Robertson _et al._ (1951), Self _et al._ (1955), Zimmerman _et al._ (1960), Christian and Nofziger (1952) and also Haines _et al._ (1959a). In addition to the above workers Gossett and Sorensen (1959, 1961) found that a high level of feed intake increased embryonic mortality when compared to a low level. Rigor _et al._ (1963) observed that embryo survival was not adversely affected by ad libitum feeding of a low fiber ration, the reverse of what was observed in previous trials from this station. McGillivray et al. (1962) observed an increase in ovulation rate and embryo survival with increased energy in the diet, in one trial with gilts, however, in another experiment McGillivray et al. (1963) observed that the ovulation rate and conception rate on a lower intake of four pounds per day gave the most desirable reproductive performance.

In those studies in which sows were allowed to farrow, Zeller (1937) in early studies observed a tendency of pigs farrowed to increase with the increased rate of gain of the sow during gestation. This is supported in work in Thrasher (1963).

Hanson et al. (1953), and Dean and Tribble (1959) in two out of three trials, observed that gilts self-fed during gestation farrowed more pigs than gilts limited in feed intake. However, no differences were observed by Frobish (1964), Bowland (1964a, 1964b), Salmon-Legagneur (1963), Meade et al. (1963), Stothers (1962), Self et al. (1960), Haines et al. (1957), Clawson et al. (1963), and Smith (1960) in the number of pigs born from sows or gilts fed various levels and sequences of full and limited feeding.

Casida (1959) suggests that the nutrient state at the time of follicular development, rather than the previous body development of the animal would appear to be of major importance in determining ovulation rate. This conclusion is based on the work of Self *et al.* (1955). Baker *et al.* (1956) in an analysis of the direct effects by standard partial regression of the ovulation rate and embryo survival on litter size indicated that survival rate is far more important than ovulation rate. Embryo survival to the 25th day was 57 percent and at day 70, 50 percent.

With the practices employed in the experiments reported herein, it would appear that flushing or increasing the level of feed intake at the time of mating does not increase the number of pigs farrowed.

If an increase in ovulation rate did occur due to the increased level of feed intake in these experiments, it is possible that the advantage obtained from flushing would not be observed due to the fact that an increased level of feed after conception increases embryonic mortality. A sow or gilt that conceived in the early part of the mating period would be on the high level of feed intake for several days after conception, a critical period for embryonic survival, thus reversing any effect of the increase in ovulation rate. Seventy-three sows of a possible eighty-seven in this study that were fed the high level at mating time remained on the high level an average of twelve days after being bred. The fourteen remaining conceived when they were on the low level of feed intake. If one were able to control the estrus cycle, all sows could be bred at the same time and feeding regimen changed accordingly.

Variations in the procedures in previous studies are responsible for some of the conflicting results. One of these is the small number of animals involved in some of the experiments. In many of the studies animals were fed in a group, and it has been shown by Rasmussen et al. (1962) that a social dominance is established in small herds of sows or gilts that are fed in a group. This increases the variation found within a pen. Another variable that may be involved is the breed of swine. Possibly flushing has more of an effect on reproduction with certain breeds. This has been shown to be true with sheep as demonstrated by Bellows et al. (1963).

Effect of Feed Level on the Birth Weight of Live Pigs

In Experiments 6317 and 6317A there were no significant differences between treatments on the birth weight of the live pigs. Those sows fed the high level of feed intake at mating time farrowed significantly heavier pigs than those fed the low level in trial three and in the combined analysis of the three trials. In some studies the birth weight was not affected by different levels of feeding, Self et al. (1960), Stothers (1962), Frobish (1964). However, Hanson et al. (1953), Dean and Tribble (1959), Clawson et al. (1963), and Pickett and Beeson (1962) reported that reducing the level of energy in the ration resulted in lighter pigs farrowed. Waite et al.

(1964) increased feeding levels from 4 to 6 pounds the last part of gestation and did not observe an increase in birth weight. However, studies by Clawson (1963), and Pickett and Beeson (1962) indicate that as the feed level goes below about four pounds per sow per day it appears that the birth weight of pigs is decreased. In the trials reported herein birth weight of pigs from sows on the low level of four pounds during the last third of gestation were not decreased significantly when compared to the birth weight of pigs farrowed by sows fed six pounds per day. The calculated metabolizable energy value of the ration used in these experiments is 1525 calories per pound. In the summer trials 1 and 3 the high level of feed intake was six pounds (9150 calories) and the low level was four pounds (6100 calories) per sow per day. The high level in the winter trial was seven pounds (10675 calories) and the low level was five pounds (7625 calories) per sow per day. The feeding of four pounds of a corn-soybean type of diet as used in the experiment reported herein may not be as limiting as it may first appear.

Effect of Feed Level on Number of Pigs Weaned and Weaning Weight

In Experiments 6317, 6317A, 6317B there were no significant treatment effects on number of pigs weaned and the average pig gain from birth to weaning. There was, however, an interaction observed in Experiment 6317B, and in the combined analysis of the three trials on the number of pigs weaned. This interaction is in part a reflection of the same effect observed in the combined analysis of the number of pigs farrowed alive.

Pickett and Beeson (1962) observed that gilts on reduced energy intake during gestation weaned more and heavier pigs than did those gilts on a higher energy ration. In one study Hanson et al. (1953) observed that gilts self-fed during gestation weaned heavier pigs than limited-fed gilts, however, in a later study the survival rate was higher for the limited-fed group. Zeller (1937) observed that the heavier sows at farrowing weaned more and heavier pigs.

Frobish (1964) observed that a greater number of sows on a high energy failed to complete 3 reproductive cycles. In addition, observations on the performance of sows during lactation by Preston and Mayrose (1963) indicates that sows that gain less during gestation are more agile and can manipulate themselves in the farrowing stall and prevent crushing and injuring somewhat better than those sows that gain excessive weight. Sows that gain less or were in a thin condition had appetites adequate to consume the quantity of feed and water needed for milk production after farrowing. Although no differences were observed in number or weight of pigs weaned in the three experiments reported herein, it would appear advantageous to keep the gain of the sow during gestation low for good lactation performance.

Effect of Feed Level on Sow Gain

In Experiment 6317 and in the combined analysis of the three trials, those sows fed the high level of feed intake during the last one-third of gestation gained significantly ($P \leq 0.01$) more than those fed the low level. This same effect was also significant ($P \leq 0.05$) in Experiment 6317A and 6317B. Also, in Experiment 6317B a highly significant interaction was found between treatments (Tables 14, 30, 46).

Sows or gilts fed a higher level of feed intake during gestation also gained more during this period. Pickett and Beeson (1962) and Frobish (1964) have reported similar results.

A larger increase in weight gain during gestation resulted in a larger loss during lactation according to the results obtained by Salmon-Legagneur (1963). This was also verified by Meade and associates (1963).

Further studies on swine reproduction could be directed toward the feeding of different levels of feed intake during the mating period. Since those sows on the high level of feed intake at mating time were maintained on the high level for an average of twelve days after conception, the period of the flushing treatment might be reduced one or two weeks. If there is an increase in ovulation rate by the higher level of feeding, the increased embryo mortality that has been reported to result from a high level of feeding would not mask the flushing effect. The effects of a high and low level of feed intake during mid-gestation could also be compared.

The animals in a reproductive study could be weighed every week or two weeks so as to follow the rate of gain throughout the gestation period.

The gilts and sows in this experiment were weaned at two weeks of age. Further research might incorporate studying the effects of feeding low levels of feed intake during gestation in a system where pigs are weaned at four, six or eight weeks of age.

In addition, the animals used in a reproductive project might be started on a controlled feeding program at weaning or soon after weaning. It appears from previous studies that the condition of the animal at the time of mating affects the ovulation rate. Gilts that are self-fed may perform differently than those that are individually-fed a limited amount of feed during the growing period. Individual feeding during the growing period may also be of value in further studies on the repeatability of litter traits. Larger numbers of animals with more control of the environmental factors would add to the information obtained from such a project.

Effect of Method of Feeding on Repeatability of Litter Traits

The repeatability coefficients for the number of pigs farrowed, the number of pigs farrowed alive and the weaning weight adjusted for number of pigs weaned were higher for the individually fed sows than for the group-fed sows.

For the total number of pigs farrowed, the repeatability coefficient was 0.33. This means that if gilts are selected that farrow one more pig than the average of the group in their first litter, that group of sows in their second and third litters will farrow 0.33 more pigs in the combined total for the two litters than if no attention were given to selection. Rathnasabapathy _et al_. (1956) state that a substantial gain in litter size is possible only by genetic improvement, supplemented by favorable environmental conditions. In this study it would appear that the feeding management methods used in these individual feeding experiments may be responsible for the higher repeatability figure for the number of pigs farrowed. With individual feeding each sow is fed a determined amount of feed, whereas, in group-feeding this may not be true. Rasmussen _et al_. (1962) has shown that a social dominance exists in herds of gilts fed in a group. Preston and Mayrose (1963) have observed that the variation is considerable between sows in the amount of time required to consume a certain amount of ration. Individual feeding insures that each animal can be fed a similar and determined amount of feed, thus removing the variation of different levels of feed intake inherent with group-fed animals.

Another factor involved is one that might be called psychological. The individual feeding method removes the competitiveness at feeding time. If psychological factors influence the number of pigs farrowed, the individual feeding method may be reducing this experimental error.

SUMMARY

Three trials involving 176 litters were conducted to study the effects of two levels of feed intake during two periods of the reproductive cycle namely at the time of mating and during the last third of gestation on the reproductive performance of swine. Sixty-four animals were maintained on the same treatments throughout three successive reproductive cycles. Criteria used to measure reproductive performance were number of pigs farrowed alive, average birth weight of live pigs, the number of pigs weaned, average pig gain from birth to weaning and the sow weight change during gestation and lactation.

In trial two the number of pigs farrowed alive from sows fed the low level of feed intake at the time of mating was significantly greater than in those fed the high level. No differences in the number of pigs farrowed alive were observed in trial one and three, however, in the combined analysis of the three trials a significant interaction between treatments was found.

Sows fed the high level of feed intake during the last one-third of gestation gained significantly more from the initiation of the experiment to weaning than those fed the low level in trial one and two and in the combined analysis of the three trials. In trial three, a significant interaction was observed between treatments on sow gain during gestation and lactation.

In trial one and two, no significant differences between treatments were observed on the birth weight of the live pigs. Those sows fed the high level of feed intake at the time of mating farrowed significantly heavier pigs than those fed the low level in trial three and in the combined analysis of the three trials.

No significant treatment effects were observed on number of pigs weaned and the average pig gain from birth to weaning in the three trials. In trial three and also in the combined analysis of the three trials a significant interaction was observed on number of pigs weaned. Sows fed either the high level or low level of feed intake during the two experimental periods weaned fewer pigs than sows fed a high level only one of the experimental periods either during breeding or during the last third of gestation.

The repeatability coefficients for the individually-fed sows were higher than those for the group-fed sows for number of pigs farrowed, number of pigs farrowed alive and for weaning weight adjusted for the number of pigs weaned, but lower for number of pigs weaned.

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APPENDIX

Table 1. Composition of rations

Ingredient	Gestation	Lactation
Ground yellow corn	81.45	76.45
Solvent soybean meal (50% protein)	13.40	13.40
Dried beet pulp	-----	5.00
Calcium carbonate (38% calcium)	0.80	0.80
Dicalcium phosphate (26% calcium) (18% phosphorous)	1.75	1.75
Iodized salt	0.50	0.50
Trace mineral premix[a]	0.10	0.10
Vitamin premix (corn carrier)[b]	2.00	2.00
Total	100.00	100.00

[a]The composition is shown in Table 4.

[b]The composition is shown in Table 3.

Table 2. Calculated analysis of rations

Item		Gestation	Lactation
Protein	Percent	14	14
Fat	Percent	3.24	3.07

Table 2. (continued)

Item		Gestation	Lactation
Fiber	Percent	2.49	3.41
Calcium	Percent	0.80	0.83
Phosphorous	Percent	0.61	0.60
Vitamin A	I.U./lb.	1837	1784
Vitamin D_2	I.U./lb.	300	300
Ribcflavin	mg./lb.	2.6	2.6
Pantothenic acid	mg./lb.	6.6	6.6
Niacin	mg./lb.	18.4	18.2
Choline	mg./lb.	341	350
Vitamin B_{12}	mcg./lb.	10	10

Table 3. Amounts of vitamins and additives added per pound of complete ration

Ingredient	Gestation	Lactation
Vitamin A, I.U.	1000	1000
Vitamin D_2, I.U.	300	300
Riboflavin, mg.	2.00	2.00
Calcium, pantothenate, mg.	4.00	4.00
Niacin, mg.	9.00	9.00
Vitamin B_{12}, mcg.	10.00	10.00

Table 3. (continued)

Ingredient	Gestation	Lactation
Iodinated casein, mg.	-----	100
Antibiotic (tylosin), mg.	-----	50

Table 4. Composition of trace mineral premix (35-C-41)

Element	Percent in premix	Parts per million contributed to the ration by 0.10%
Iron	7.000	70.4
Copper	0.475	4.8
Cobalt	0.166	1.6
Zinc	8.100	81.6
Manganese	5.680	56.8
Calcium	5.280	----
Potassium	0.750	7.5

Table 5. Experiment 6317 - summary of the number of pigs farrowed alive

		Treatment			
Breeding		H	H	L	L
Gestation		H	L	H	L
Pen	Rep.				
I	1	10	10	8	6
	2	9	13	8	8
	3	8	8	13	9
	4	9	13	11	12
II	5	11	8	11	9
	6	9	9	11	11
	7	6	11	10	4
	8	12	13	14	8
III	9	8	--	11	7
	10	6	4	11	10
	11	11	13	9	11
	12	--	--	5	10
IV	13	10	--	12	12
	14	9	10	8	8
	15	2	--	8	11
	16	2	10	8	--
Average		8.1	10.1	9.9	9.1

Table 6. Experiment 6317 - analysis of variance for number of pigs farrowed alive

Source of variation	Degrees of freedom		Mean square
Pens	3		6.00
Treatment	3		11.66
Breeding HH, HL, vs. LH, LL		1	3.00
Gestation HH, LH, vs. HL, LL		1	4.00
Interaction		1	28.00
Pens x Treatment	9		5.78
Error	42		6.93
Total	57		6.95

Table 7. Experiment 6317 - summary of the average birth weight of live pigs

Breeding Gestation Pen	Rep.	H H	H L	L H	L L
		Treatment			
I	1	3.1	3.4	3.8	4.0
	2	3.0	3.3	3.1	3.8
	3	3.0	3.2	2.1	3.5
	4	3.3	2.1	3.5	2.6
II	5	3.5	2.9	3.0	3.4
	6	3.3	3.7	2.3	2.7
	7	2.6	3.5	3.0	4.2
	8	2.6	2.5	2.6	3.2
III	9	4.1	---	2.7	3.1
	10	3.3	3.6	2.8	3.6
	11	3.1	2.5	3.1	3.1
	12	---	---	3.4	2.6
IV	13	3.2	---	2.8	3.0
	14	3.0	3.0	3.3	2.6
	15	2.6	---	2.9	3.2
	16	3.4	2.3	2.7	---
Average		3.1	3.0	2.9	3.2

Table 8. Experiment 6317 - analysis of variance for average birth weight of live pigs

Source of variation	Degrees of freedom		Mean Square
Pens	3		0.18
Treatment	3		0.27
Breeding HH, HL, vs. LH, LL		1	----
Gestation HH, HL, vs. HL, LL		1	0.13
Interaction		1	0.67
Pens x treatment	9		0.15
Error	42		0.24
Total	57		0.22

Table 9. Experiment 6317 - summary of number of pigs weaned

		Treatment			
Breeding		H	H	L	L
Gestation		H	L	H	L
Pen	Rep.				
I	1	9	7	8	6
	2	7	3	3	8
	3	7	7	8	9
	4	9	9	9	7
II	5	6	8	9	8
	6	9	9	9	11
	7	0	8	9	0
	8	8	5	7	5
III	9	7	-	10	7
	10	5	4	11	9
	11	8	2	6	4
	12	-	-	5	7
IV	13	9	-	11	5
	14	-	8	1	8
	15	0	-	7	10
	16	2	8	7	--
Average		6.1	6.5	7.5	6.9

Table 10. Experiment 6317 - analysis of variance for number of pigs weaned

Source of variation	Degrees of freedom		Mean Square
Pens	3		2.33
Treatment	3		5.00
Breeding HH, HL, vs. LH, LL		1	12.00
Gestation HH, LH, vs. HL, LL		1	----
Interaction		1	3.00
Pens x treatment	9		8.55
Error	41		8.05
Total	56		7.66

Table 11. Experiment 6317 - summary of the average pig gain birth to weaning

		Treatment			
Breeding		H	H	L	L
Gestation		H	L	H	L
Pen	Rep.				
I	1	5.4	5.7	5.9	4.7
	2	4.7	0.6	0.9	5.9
	3	5.8	6.5	4.0	5.0
	4	3.1	6.4	6.5	2.9
II	5	8.2	6.9	5.3	6.4
	6	4.2	7.0	5.6	3.2
	7	---	2.6	5.2	---
	8	5.5	4.1	2.9	3.2
III	9	5.2	---	3.8	5.7
	10	3.7	7.7	2.8	5.5
	11	3.2	1.2	3.4	2.3
	12	---	---	7.2	2.8
IV	13	3.3	---	3.4	4.5
	14	---	5.3	1.2	5.2
	15	---	---	4.6	5.9
	16	5.9	5.6	3.5	---
Average		4.8	5.0	4.1	4.5

Table 12. Experiment 6317 - analysis of variance for average pig gain birth to weaning

Source of variation	Degrees of freedom		Mean square
Pens	3		1.69
Treatment	3		1.95
Breeding HH, HL, vs. LH, LL		1	4.71
Gestation HH, LH, vs. HL, LL		1	1.05
Interaction		1	0.09
Pens x treatment	9		1.10
Error	38		3.70
Total	53		3.05

Table 13. Experiment 6317 - summary of the sow weight change from initial to weaning

		Treatment			
Breeding		H	H	L	L
Gestation		H	L	H	L
Pen	Rep.				
I	1	94	68	79	82
	2	87	95	111	55
	3	92	71	116	82
	4	63	96	74	102
II	5	114	115	65	72
	6	120	106	98	95
	7	--	105	96	--
	8	97	103	118	115
III	9	144	--	81	97
	10	113	102	104	89
	11	104	117	121	75
	12	--	--	113	101
IV	13	92	--	84	64
	14	--	52	121	94
	15	--	--	104	74
	16	143	79	120	--
Average		105	92	100	86

Table 14. Experiment 6317 - analysis of variance for the sow weight change from initial to weaning

Source of variation	Degrees of freedom		Mean square
Pens	3		1214
Treatment	3		1007[a]
Breeding HH, HL, vs. LH, LL		1	394
Gestation HH, LH, vs. HL, LL		1	2543[b]
Interaction		1	84
Pens x treatment	9		461
Error	38		300
Total	53		419

[a]Significant effect at P = .05 or less

[b]Significant effect at P = 0.01 or less

Table 15. Experiment 6317 - summary of the average number of pigs farrowed alive and dead

		Treatment			
Pen	Breeding Gestation	H H	H L	L H	L L
I		10.2	11.2	10.5	9.0
II		11.5	11.5	12.0	8.5
III		9.3	9.0	10.0	10.5
IV		10.0	10.0	9.8	10.7
Average		10.2	10.4	10.6	9.7

Table 16. Experiment 6317 - summary of the average percent born dead

		Treatment			
Pen	Breeding Gestation	H H	H L	L H	L L
I		12.2	1.8	4.5	3.5
II		16.2	10.0	4.2	5.0
III		12.0	10.0	9.2	10.0
IV		40.0	0.0	7.8	2.7
Average		20.1	5.4	6.4	5.3

Table 17. Experiment 6317 - summary of the average percent of the live pigs farrowed that were weaned

		Treatment			
Pen	Breeding Gestation	H H	H L	L H	L L
I		89	62	70	90
II		56	78	76	63
III		81	58	90	74
IV		63	80	70	78
Average		72	70	76	76

Table 18. Experiment 6317 - Summary of the number of days from the start of mating to farrowing

		Treatment			
Breeding Gestation Pen	Rep.	H H	H L	L H	L L
I	1	128	125	118	133
	2	129	148	152	129
	3	118	129	151	128
	4	120	117	118	152
II	5	132	127	116	125
	6	129	150	124	118
	7	126	128	128	119
	8	118	132	116	137
III	9	153	126	193	151
	10	128	175	162	151
	11	113	125	151	127
	12	---	---	130	132
IV	13	119	---	128	126
	14	---	132	124	116
	15	132	---	117	148
	16	170	116	120	---
Average		130	133	134	133
Number conceived 1st estrus		12	10	11	10
Did not conceive 1st estrus[a]		2	3	5	5

[a]Over 135 days.

Table 19. Experiment 6317 - summary of average daily feed consumption (lb.) during lactation

		Treatment			
Breeding		H	H	L	L
Gestation		H	L	H	L
Pen	Rep.				
I	1	7.6	7.2	7.6	6.4
	2	5.7	7.6	6.2	6.1
	3	6.9	6.1	6.6	7.9
	4	7.1	8.0	8.6	7.8
II	5	8.8	9.0	8.6	7.2
	6	8.9	9.2	8.2	9.8
	7	---	7.6	8.5	---
	8	8.2	9.9	8.3	10.1
III	9	8.3	---	9.6	9.8
	10	9.2	8.7	9.2	9.9
	11	9.5	9.6	9.2	5.7
	12	---	---	9.2	10.1
IV	13	8.5	---	10.1	9.8
	14	---	10.0	9.6	10.0
	15	---	---	8.6	6.7
	16	9.5	8.2	9.9	---
Average		8.2	8.4	8.6	8.4

Table 20. Experiment 6317 - summary of the total feed consumption (lb.) from initial to weaning

		Treatment			
Breeding Gestation		H H	H L	L H	L L
Pen	Rep.				
I	1	848	746	711	722
	2	823	831	894	694
	3	771	746	894	722
	4	796	742	745	783
II	5	924	820	719	689
	6	884	895	771	681
	7	---	791	788	---
	8	797	826	713	767
III	9	999	---	1177	906
	10	850	862	1047	909
	11	762	777	944	652
	12	---	---	789	731
IV	13	806	---	811	732
	14	---	846	805	678
	15	---	---	713	780
	16	1122	718	747	---
Average		865	800	829	746

Table 21. Experiment 6317A - summary of the number of pigs farrowed alive

		Treatment			
Breeding		H	H	L	L
Gestation		H	L	H	L
Pen	Rep.				
I	1	11	--	16	14
	2	13	10	13	8
	3	12	11	--	11
	4	10	11	13	11
II	5	12	13	12	--
	6	12	6	11	11
	7	11	12	--	12
	8	10	8	11	11
III	9	10	11	10	11
	10	10	8	10	11
	11	10	9	8	11
	12	10	13	10	12
IV	13	11	12	12	12
	14	6	12	10	13
	15	8	11	10	10
	16	6	9	--	11
Average		10.1	10.4	11.2	11.3

Table 22. Experiment 6317A - analysis of variance for the number of pigs farrowed alive

Source of variation	Degrees of freedom		Mean square
Pens	3		7.33
Treatment	3		5.00
Breeding HH, HL, vs. LH, LL		1	15.00[a]
Gestation HH, LH, vs. HL, LL		1	1.00
Interaction		1	1.00
Pens x treatment	9		5.89
Error	43		2.70
Total	58		3.55

[a]Significant effect at P = .05 or less.

Table 23. Experiment 6317A - summary of the average birth weight of live pigs

		Treatment			
Breeding		H	H	L	L
Gestation		H	L	H	L
Pen	Rep.				
I	1	3.1	---	3.0	2.7
	2	2.7	3.4	3.6	3.4
	3	3.0	3.5	---	3.5
	4	3.1	2.8	2.6	3.7
II	5	4.2	2.6	3.2	---
	6	2.8	4.0	2.6	2.9
	7	3.4	3.5	---	3.5
	8	3.0	4.3	3.4	3.2
III	9	4.0	3.6	3.9	3.0
	10	3.8	3.9	3.7	3.1
	11	3.2	3.1	3.4	2.9
	12	4.0	2.4	3.2	3.0
IV	13	3.2	2.8	3.2	3.0
	14	3.4	2.6	3.6	2.9
	15	4.0	3.1	3.3	3.6
	16	3.6	3.2	---	3.4
Average		3.4	3.2	3.3	3.2

Table 24. Experiment 6317A - analysis of variance for birth weight of live pigs

Source of variation	Degrees of freedom		Mean square
Pens	3		0.15
Treatment	3		0.13
Breeding HH, HL, vs. LH, LL		1	0.15
Gestation HH, LH, vs. HL, LL		1	0.26
Interaction		1	----
Pens x treatment	9		0.29
Error	43		0.18
Total	58		0.19

Table 25. Experiment 6317A - summary of the number of pigs weaned

		Treatment			
Breeding		H	H	L	L
Gestation		H	L	H	L
Pen	Rep.				
I	1	9	--	13	11
	2	8	8	12	5
	3	10	5	--	11
	4	9	10	9	10
II	5	11	8	12	--
	6	9	6	10	10
	7	10	10	--	7
	8	3	7	9	10
III	9	3	10	10	8
	10	9	8	10	9
	11	9	9	8	2
	12	10	9	7	12
IV	13	11	11	8	11
	14	6	9	10	13
	15	8	10	9	9
	16	6	9	--	9
Average		8.1	8.6	9.8	9.1

Table 26. Experiment 6317A - analysis of variance for number of pigs weaned

Source of variation	Degrees of freedom		Mean square
Pens	3		3.33
Treatment	3		6.67
Breeding HH, HL, vs. LH, LL		1	16.00
Gestation HH, LH, vs. HL, LL		1	-----
Interaction		1	4.00
Pens x treatment	9		3.89
Error	43		5.37
Total	58		5.10

Table 27. Experiment 6317A - summary of the average pig gain birth to weaning

Breeding / Gestation		H / H	H / L	L / H	L / L
		Treatment			
Pen	Rep.				
I	1	6.0	---	5.3	6.3
	2	7.0	6.7	2.8	7.1
	3	6.2	8.2	---	5.3
	4	6.6	5.2	5.6	1.2
II	5	6.7	5.1	4.7	4.6
	6	2.9	7.9	5.4	3.6
	7	5.6	3.3	---	5.4
	8	5.4	7.8	2.8	---
III	9	0.9	2.6	6.5	5.8
	10	8.1	7.2	4.5	3.4
	11	5.7	5.7	7.1	6.1
	12	5.2	5.0	8.2	5.1
IV	13	5.2	5.8	5.2	4.8
	14	8.3	6.6	5.8	5.1
	15	8.1	4.9	5.0	6.4
	16	7.5	6.0	---	4.1
Average		6.0	5.9	5.3	5.0

Table 28. Experiment 6317A - analysis of variance for pig gain birth to weaning

Source of variation	Degrees of freedom		Mean square
Pens	3		1.83
Treatment	3		3.46
Breeding HH, HL, vs. LH, LL		1	9.47
Gestation HH, LH, vs. HL, LL		1	0.96
Interaction		1	----
Pens x treatment	9		2.79
Error	43		2.76
Total	58		2.75

Table 29. Experiment 6317A - summary of the sow weight change from initial to weaning

		Treatment			
Breeding		H	H	L	L
Gestation		H	L	H	L
Pen	Rep.				
I	1	54	--	58	-1
	2	55	58	57	61
	3	27	72	--	3
	4	26	72	55	29
II	5	40	68	26	--
	6	89	21	80	74
	7	19	63	--	46
	8	--	61	84	46
III	9	105	72	73	76
	10	66	49	41	67
	11	78	85	94	90
	12	73	39	72	77
IV	13	68	42	62	56
	14	96	33	81	49
	15	91	75	87	46
	16	87	82	--	50
Average		65	59	67	51

Table 30. Experiment 6317A - analysis of variance for sow weight change from initial to weaning

Source of variation	Degrees of freedom		Mean square
Pens	3		2242
Treatments	3		708
Breeding HH, HL, vs. LH, LL		1	194
Gestation HH, LH, vs. HL, LL		1	1594[a]
Interaction		1	337
Pens x treatment	9		677
Error	42		392
Total	57		551

[a]Significant effect at P = .05 or less.

Table 31. Experiment 6317A - summary of the average number of pigs farrowed alive and dead

Pen	Breeding Gestation	H H	H L	L H	L L
		Treatment			
I		11.5	11.0	14.0	12.5
II		12.0	10.0	11.3	11.3
III		10.2	10.8	10.2	11.5
IV		7.8	11.5	10.7	11.8
Average		10.4	10.8	11.6	11.8

Table 32. Experiment 6317A - summary of the average percent born dead

Pen	Breeding Gestation	H H	H L	L H	L L
		Treatment			
I		0.0	3.0	0.0	12.0
II		5.8	1.8	0.0	0.0
III		2.2	4.5	6.5	2.0
IV		0.0	4.5	0.0	1.8
Average		2.0	3.4	1.6	4.0

Table 33. Experiment 6317A - summary of the average percent of live pigs farrowed that were weaned

Pen	Breeding Gestation	H H	H L	L H	L L
		Treatment			
I		79	72	81	83
II		72	83	91	80
III		78	90	92	68
IV		100	90	86	91
Average		82	84	88	80

Table 34. Experiment 6317A - summary of the number of days from the start of mating to farrowing

		Treatment			
Breeding		H	H	L	L
Gestation		H	L	H	L
Pen	Rep.				
I	1	126	---	130	114
	2	127	128	124	117
	3	129	125	---	126
	4	115	127	125	132
II	5	136	122	123	---
	6	122	119	126	119
	7	115	119	---	127
	8	125	136	124	119
III	9	155	141	118	127
	10	126	123	140	123
	11	126	129	122	147
	12	119	165	132	145
IV	13	124	118	122	123
	14	123	119	123	119
	15	119	122	126	115
	16	117	118	---	126
Average		125	127	126	125
Number conceived 1st estrus		14	12	12	13
Did not conceive 1st estrus[a]		2	3	1	2

[a]Over 135 days.

Table 35. Experiment 6317A - summary of average daily feed consumption (lb.) during lactation

		Treatment			
Breeding Gestation		H H	H L	L H	L L
Pen	Rep.				
I	1	10.4	---	10.4	10.9
	2	9.8	8.7	7.3	9.1
	3	7.8	10.6	---	7.1
	4	7.1	8.8	9.4	5.7
II	5	9.6	8.9	9.7	---
	6	8.6	11.4	6.5	11.6
	7	10.0	7.0	---	9.5
	8	8.9	10.2	10.2	10.6
III	9	8.7	10.1	9.4	10.0
	10	10.2	10.2	7.9	7.9
	11	10.1	10.4	10.3	6.7
	12	9.6	8.4	9.4	9.4
IV	13	8.6	9.2	7.1	7.8
	14	8.3	9.1	8.1	8.7
	15	5.8	7.1	7.6	6.8
	16	8.1	8.0	---	7.0
Average		8.8	9.2	8.7	8.6

Table 36. Experiment 6317A - summary of the total feed consumption (lb.) from initial to weaning

		Treatment			
Breeding Gestation		H H	H L	L H	L L
Pen	Rep.				
I	1	1056	---	978	823
	2	997	925	877	815
	3	988	919	---	822
	4	877	914	924	820
II	5	812	931	915	---
	6	959	912	878	846
	7	943	857	---	856
	8	1001	1029	923	851
III	9	1184	987	873	861
	10	1014	913	1015	803
	11	1012	969	911	906
	12	957	1205	987	954
IV	13	963	867	855	805
	14	950	903	877	824
	15	873	855	899	746
	16	909	845	---	809
Average		968	935	916	836

Table 37. Experiment 6317B - summary of the number of pigs farrowed alive

		Treatment			
Breeding		H	H	L	L
Gestation		H	L	H	L
Pen	Rep.				
I	1	11	11	16	13
	2	9	11	15	7
	3	8	11	12	9
	4	11	8	11	7
II	5	7	14	8	10
	6	9	9	9	12
	7	--	11	7	5
	8	12	13	11	--
III	9	12	14	11	17
	10	11	9	6	10
	11	--	9	--	6
	12	10	9	10	10
IV	13	5	8	10	7
	14	6	7	14	9
	15	--	11	9	11
	16	10	12	11	9
Average		9.3	10.4	10.7	9.5

Table 38. Experiment 6317B - analysis of variance for the number of pigs farrowed alive

Source of variation	Degrees of freedom		Mean square
Pens	3		5.37
Treatment	3		6.74
Breeding HH, HL, vs. LH, LL		1	0.27
Gestation HH, LH, vs. HL, LL		1	0.07
Interaction		1	19.88
Pens x treatment	9		9.39
Error	43		6.21
Total	58		6.69

Table 39. Experiment 6317B - summary of the average birth weight of live pigs

Pen	Rep.	Treatment: Breeding H, Gestation H	Breeding H, Gestation L	Breeding L, Gestation H	Breeding L, Gestation L
I	1	2.9	2.7	2.6	2.4
	2	2.9	2.6	2.2	3.0
	3	4.0	3.2	2.6	3.4
	4	3.0	2.9	2.8	3.5
II	5	3.1	3.4	2.7	2.0
	6	3.7	4.1	3.9	2.9
	7	---	3.2	3.1	2.0
	8	2.8	3.2	2.5	---
III	9	2.4	2.9	3.0	2.2
	10	3.0	3.5	3.6	2.7
	11	---	3.2	---	3.2
	12	3.0	3.3	2.8	2.5
IV	13	3.7	3.8	2.5	4.1
	14	4.0	3.1	2.7	2.5
	15	---	3.0	4.1	3.2
	16	3.5	3.8	3.2	3.4
Average		3.2	3.2	3.0	2.9

Table 40. Experiment 6317B - analysis of variance for birth weight of live pigs

Source of variation	Degrees of freedom		Mean square
Pens	3		0.65
Treatment	3		0.55
Breeding HH, HL, vs. LH, LL		1	1.58[a]
Gestation HH, LH, vs. HL, LL		1	0.01
Interaction		1	0.05
Pens x treatment	9		0.37
Error	43		0.22
Total	58		0.28

[a]Significant effect at P = 0.05 or less.

Table 41. Experiment 6317B - summary of the number of pigs weaned

		Treatment			
Breeding		H	H	L	L
Gestation		H	L	H	L
Pen	Rep.				
I	1	8	9	12	10
	2	5	9	11	5
	3	6	8	9	6
	4	9	7	10	7
II	5	6	10	7	7
	6	6	8	9	11
	7	--	9	4	0
	8	7	12	8	--
III	9	9	14	11	13
	10	11	9	6	6
	11	--	9	--	1
	12	10	8	7	7
IV	13	5	8	8	7
	14	6	5	13	6
	15	--	7	6	7
	16	8	7	9	7
Average		7.4	8.7	8.7	6.7

Table 42. Experiment 6317B - analysis of variance for number of pigs weaned

Source of variation	Degrees of freedom		Mean square
Pens	3		6.05
Treatment	3		14.99
Breeding HH, HL, vs. LH, LL		1	2.81
Gestation HH, LH, vs. HL, LL		1	1.92
Interaction		1	40.25[a]
Pens x treatment	9		7.22
Error	43		6.14
Total	58		6.76

[a]Significant effect at P = 0.05 or less.

Table 43. Experiment 6317B - summary of the average pig gain birth to weaning

Breeding Gestation Pen	Rep.	H H	H L	L H	L L
I	1	5.2	6.3	6.5	5.8
	2	6.7	7.4	5.0	7.6
	3	9.0	4.3	5.3	9.1
	4	6.6	6.5	4.7	7.7
II	5	5.0	5.4	7.3	4.8
	6	6.4	6.6	7.5	4.3
	7	---	5.8	8.0	---
	8	5.0	5.6	3.9	---
III	9	8.1	4.9	6.6	4.3
	10	6.9	5.3	7.4	5.8
	11	---	5.9	---	10.2
	12	4.9	7.2	7.7	6.3
IV	13	7.7	5.9	7.3	6.7
	14	5.5	4.1	4.2	5.4
	15	---	5.8	7.1	7.9
	16	6.8	7.7	6.2	7.5
Average		6.4	5.9	6.3	6.7

(Treatment spans columns H H, H L, L H, L L.)

Table 44. Experiment 6317B - analysis of variance for pig gain birth to weaning

Source of variation	Degrees of freedom		Mean square
Pens	3		1.48
Treatment	3		1.51
Breeding HH, HL, vs. LH, LL		1	1.59
Gestation HH, LH, vs. HL, LL		1	0.17
Interaction		1	2.76
Pens x treatment	9		2.06
Error	42		1.89
Total	57		1.87

Table 45. Experiment 6317B - summary of the sow weight change from initial to weaning

		Treatment			
Breeding		H	H	L	L
Gestation		H	L	H	L
Pen	Rep.				
I	1	123	93	73	52
	2	111	69	87	102
	3	74	98	125	95
	4	101	85	89	94
II	5	120	64	78	86
	6	105	66	74	68
	7	---	80	80	--
	8	92	51	79	--
III	9	39	-4	-25	39
	10	74	17	78	28
	11	---	-8	---	--
	12	90	20	52	11
IV	13	93	66	26	75
	14	74	63	45	32
	15	---	74	57	76
	16	77	30	36	46
Average		90	54	64	62

Table 46. Experiment 6317B - analysis of variance for sow weight change from initial to weaning

Source of variation	Degrees of freedom		Mean square
Pens	3		9903
Treatment	3		3409
Breeding HH, HL, vs. LH, LL		1	291
Gestation HH, LH, vs. HL, LL		1	4848[a]
Interaction		1	5089[a]
Pens x treatment	9		307
Error	41		420
Total	56		1070

[a]Significant effect at P = 0.01 or less.

Table 47. Experiment 6317B - summary of the average number of pigs farrowed alive and dead

Pen	Breeding Gestation	H H	H L	L H	L L
		Treatment			
I		10.8	10.5	13.5	10.2
II		10.3	11.8	9.0	11.3
III		12.0	12.2	10.0	11.2
IV		7.7	9.8	12.5	10.0
Average		10.2	11.1	11.2	10.7

Table 48. Experiment 6317B - summary of the average percent born dead

Pen	Breeding Gestation	H H	H L	L H	L L
		Treatment			
I		8.2	2.0	0	11.8
II		8.8	0	2.8	22.3
III		6.7	15.8	8.0	4.5
IV		8.3	2.0	9.5	7.8
Average		8.0	5.0	5.1	11.6

Table 49. Experiment 6317B - summary of the average percent of live pigs farrowed that were weaned

Pen	Breeding Gestation	H H	H L	L H	L L
		Treatment			
I		72	81	78	79
II		70	84	80	54
III		92	97	90	56
IV		93	73	80	77
Average		82	84	82	66

Table 50. Experiment 6317B - summary of the number of days from the start of mating to farrowing

		Treatment			
Breeding Gestation		H H	H L	L H	L L
Pen	Rep.				
I	1	131	119	119	126
	2	122	125	116	120
	3	108	120	131	122
	4	120	158	126	130
II	5	143	144	146	130
	6	130	115	122	124
	7	---	126	119	123
	8	117	122	131	---
III	9	129	119	126	117
	10	120	126	119	133
	11	---	136	---	138
	12	163	115	118	124
IV	13	118	118	118	134
	14	155	116	138	120
	15	---	118	124	118
	16	145	121	133	169
Average		131	125	126	129
Number conceived 1st estrus		9	13	13	13
Did not conceive 1st estrus[a]		4	3	2	2

[a]Over 135 days.

Table 51. Experiment 6317B - summary of the average daily feed consumption (lb.) during lactation

		Treatment			
Breeding Gestation		H H	H L	L H	L L
Pen	Rep.				
I	1	11.1	10.1	11.1	12.5
	2	10.3	8.6	10.2	10.4
	3	10.2	11.5	14.2	11.2
	4	11.6	11.1	13.0	13.2
II	5	12.6	11.5	11.6	13.4
	6	14.1	11.8	11.8	12.3
	7	----	14.0	11.5	----
	8	12.4	11.8	13.5	----
III	9	11.4	12.1	12.1	13.2
	10	11.7	12.1	11.8	11.2
	11	----	11.8	----	11.5
	12	12.1	10.8	11.4	11.0
IV	13	11.8	12.2	7.9	12.6
	14	10.0	11.0	12.3	6.4
	15	----	11.4	12.1	12.1
	16	12.5	11.2	10.5	----
Average		11.7	11.4	11.7	11.6

Table 52. Experiment 6317B - summary of the total feed consumption (lb.) from initial to weaning

		Treatment			
Breeding		H	H	L	L
Gestation		H	L	H	L
Pen	Rep.				
I	1	935	756	772	744
	2	838	751	761	684
	3	753	771	873	723
	4	840	942	826	753
II	5	1018	1013	963	811
	6	959	811	870	736
	7	---	903	767	---
	8	897	808	906	---
III	9	930	803	837	783
	10	859	831	791	760
	11	---	858	---	807
	12	1142	778	773	770
IV	13	848	793	718	819
	14	1048	800	975	632
	15	---	765	831	723
	16	1190	774	854	---
Average		943	822	834	750

Table 53. Experiment 6317, 6317A, 6317B - summary of the number of pigs farrowed alive

		Treatment			
Experiment	Breeding Gestation	H H	H L	L H	L L
6317		8.1	10.1	9.9	9.1
6317A		10.1	10.4	11.2	11.3
6317B		9.3	10.4	10.7	9.5
Average[a]		9.2	10.3	10.5	9.9

[a]Average of the individual values.

Table 54. Experiments 6317, 6317A, 6317B - analysis of variance for average number of pigs farrowed alive

Source of variation	Degrees of freedom	Mean square
Cells (Animals on the same treatment w/pen)	47	12.47
Treatment	3	15.33
Breeding HH, HL vs. LH, LL	1	10.00
Gestation HH, LH vs. HL, LL	1	3.00
Interaction	1	33.00[a]
Error	126	5.34
Total	173	6.08

[a]Significant at P = 0.05 or less.

Table 55. Experiments 6317, 6317A, 6317B - summary of the average birth weight of live pigs

Experiment	Breeding Gestation	H H	H L	L H	L L
		Treatment			
6317		3.1	3.0	2.9	3.2
6317A		3.4	3.2	3.3	3.2
6317B		3.2	3.2	3.0	2.9
Average[a]		3.2	3.2	3.0	3.1

[a]Average of the individual values.

Table 56. Experiments 6317, 6317A, 6317B - analysis of variance for average birth weight of live pigs

Source of variation	Degrees of freedom	Mean square
Cells	47	0.31
Treatment	3	0.40
Breeding HH, HL, vs. LH, LL	1	0.97[a]
Gestation HH, LH, vs. HL, LL	1	0.02
Interaction	1	0.20
Error	126	0.22
Total	173	0.24

[a]Significant at P = 0.05 or less.

Table 57. Experiments 6317, 6317A, 6317B - summary of the average number of pigs weaned

Experiment	Breeding Gestation	Treatment H H	 H L	 L H	 L L
6317		6.1	6.5	7.5	6.9
6317A		8.1	8.6	9.8	9.1
6317B		7.4	8.7	8.7	6.7
Average[a]		7.3	8.0	8.6	7.6

[a]Average of individual values.

Table 58. Experiments 6317, 6317A, 6317B - analysis of variance for number of pigs weaned

Source of variation	Degrees of freedom			Mean square
Cells	47			8.87
Treatment		3		13.67
Breeding HH, HL vs. LH, LL			1	7.00
Gestation HH, LH vs. HL, LL			1	0
Interaction			1	34.00[a]
Error	127			6.60
Total	172			7.22

[a]Significant at P = 0.05 or less.

Table 59. Experiments 6317, 6317A, 6317B - summary of the average pig gain birth to weaning

Experiment	Breeding Gestation	H H	H L	L H	L L
		Treatment			
6317		4.8	5.0	4.1	4.5
6317A		6.0	5.9	5.3	5.0
6317B		6.5	5.9	6.3	6.8
Average[a]		5.8	5.6	5.2	5.4

[a]Average of individual values.

Table 60. Experiments 6317, 6317A, 6317B - analysis of variance for average pig gain from birth to weaning

Source of variation	Degrees of freedom			Mean square
Cells	47			3.71
Treatment		3		2.78
Breeding HH, HL vs. LH, LL			1	7.37
Gestation HH, LH vs. HL, LL			1	0
Interaction			1	0.97
Error	121			2.80
Total	168			3.05

Table 61. Experiments 6317, 6317A, 6317B - summary of the sow weight change from initial to weaning

Experiment	Breeding Gestation	Treatment H H	 H L	 L H	 L L
6317		105	92	100	86
6317A		65	59	67	51
6317B		90	54	64	62
Average[a]		85	67	78	66

[a]Average of the individual values.

Table 62. Experiments 6317, 6317A, 6317B - analysis of variance for sow weight change from initial to weaning

Source of variation	Degrees of freedom			Mean square
Cells	47			2297
Treatment		3		3598
Breeding HH, HL vs. LH, LL			1	524
Gestation HH, LH vs. HL, LL			1	9662[a]
Interaction			1	607
Error	119			379
Total	166			922

[a]Significant at P = 0.01 or less.

Table 63. Experiments 6317, 6317A, 6317B - summary of average number of pigs farrowed alive and dead

		Treatment			
	Breeding	H	H	L	L
Experiment	Gestation	H	L	H	L
6317		10.2	10.4	10.6	9.7
6317A		10.4	10.8	11.6	11.8
6317B		10.2	11.1	11.2	10.7
Average[a]		10.3	10.9	11.1	10.7

[a]Average of the individual values.

Table 64. Experiments 6317, 6317A, 6317B - summary of average percent of pigs born dead

		Treatment			
	Breeding	H	H	L	L
Experiment	Gestation	H	L	H	L
6317		20.1	5.4	6.4	5.3
6317A		2.0	3.4	1.6	4.0
6317B		8.0	5.0	5.1	11.6
Average[a]		10.4	4.6	4.6	6.9

[a]Average of the individual value.

Table 65. Experiments 6317, 6317A, 6317B - summary of average percent of live pigs farrowed that were weaned

Experiment	Breeding / Gestation	Treatment H / H	H / L	L / H	L / L
6317		72	70	76	76
6317A		82	84	88	80
6317B		82	84	82	66
Average[a]		79	80	82	75

[a]Average of individual values.

Table 66. Experiment 6317, 6317A, 6317B - summary of the average number of days from the start of breeding to farrowing

Experiment	Breeding / Gestation	Treatment H / H	H / L	L / H	L / L
6317		130	132	134	133
6317A		125	128	126	125
6317B		132	125	126	128
Average[a]		128	128	129	129

[a]Average of individual values.

Table 67. Experiments 6317, 6317A, 6317B-summary of average daily feed consumption (lb.) during lactation

		Treatment			
Experiment	Breeding Gestation	H H	H L	L H	L L
6317		8.2	8.4	8.6	8.4
6317A		8.8	9.2	8.7	8.6
6317B		11.7	11.4	11.7	11.6
Average[a]		9.6	9.8	9.7	9.7

[a]Average of individual values.

Table 68. Experiments 6317, 6317A, 6317B - summary of the average total feed consumption (lb.) from initial to weaning

		Treatment			
Experiment	Breeding Gestation	H H	H L	L H	L L
6317		865	800	829	746
6317A		968	935	916	836
6317B		943	822	834	779
Average[a]		930	856	859	779

[a]Average of individual values.

Table 69. Experiments 6317, 6317A, 6317B - summary of the feed required (lb.) per pig weaned[a]

Experiment	Breeding Gestation	Treatment H H	H L	L H	L L
6317		142	123	111	108
6317A		120	109	93	92
6317B		127	94	96	112
Average		127	107	100	103

[a]Computed from the data from Tables 57 and 68.

Table 70. Summary of repeatability coefficients for Yorkshire x Landrace sows

Feeding method	Combined	Individual	Group
Number of pigs farrowed	0.29	0.33[a]	0.23
Pigs farrowed alive	0.18	0.19	0.16
Number of pigs weaned	0.10	0.07	0.14
Weaning weight adjusted for number of pigs weaned	0.13	0.25	-0.06

[a]Repeatability coefficients computed as follows:
From table 72:

$$\sigma^2_{S/R} = \frac{14.28 - 5.79}{3} = 2.83$$

$$r = \frac{2.83}{2.83 + 5.79} = 0.33.$$

Table 71. Summary of regression coefficients

Breed	Landrace		Yorkshire x Landrace	
Feeding method	Individual	Group	Individual	Group
Number of pigs farrowed	0.26	0.09	0.90[a]	0.51[b]
Pigs farrowed alive	0.70	0.06	0.53[a]	0.37
Number of pigs weaned	0.17	0.50[b]	0.38[b]	0.16

[a]Significant at P = 0.01 or less.

[b]Significant at P = 0.05 or less.

Table 72. Analysis of variance for total number of pigs farrowed from Yorkshire x Landrace sows fed individually

Source of variation	Degrees of freedom	Mean square
Litter order	2	31.45
Sows	79	14.28
Error	158	5.79
Total	239	8.81

Table 73. Analysis of variance for total number of pigs farrowed from Yorkshire x Landrace sows group-fed

Source of variation	Degrees of freedom	Mean square
Litter order	2	55.61
Sows	48	12.02
Error	96	6.27
Total	146	8.84

Table 74. Analysis of variance for number of pigs farrowed alive from Yorkshire x Landrace sows fed individually

Source of variation	Degrees of freedom	Mean square
Litter order	2	15.31
Sows	79	10.24
Error	158	6.02
Total	239	7.50

Table 75. Analysis of variance for number of pigs farrowed alive from Yorkshire x Landrace sows group-fed

Source of variation	Degrees of freedom	Mean square
Litter order	2	79.19
Sows	48	9.01
Error	96	5.78
Total	146	7.85

Table 76. Analysis of variance for number of pigs weaned from Yorkshire x Landrace sows fed individually

Source of variation	Degrees of freedom	Mean square
Litter order	2	66.70
Sows	79	9.41
Error	158	7.58
Total	239	8.68

Table 77. Analysis of variance for number of pigs weaned from Yorkshire x Landrace sows group-fed

Source of variation	Degrees of freedom	Mean square
Litter order	2	89.99
Sows	48	9.85
Error	96	6.68
Total	146	8.86

Table 78. Analysis of variance for total number of pigs farrowed from Yorkshire x Landrace sows fed individually and group-fed combined

Source of variation	Degrees of freedom	Mean square
Feeding method	1	66.64
Sows within ration	127	13.42
Litter order within feeding method	4	43.53
Error	254	5.97
Total	386	8.97

Table 79. Analysis of variance for number of pigs farrowed alive from Yorkshire x Landrace sows fed individually and group-fed combined

Source of variation	Degrees of freedom	Mean square
Feeding method	1	36.94
Sows within ration	127	9.78
Litter order within feeding method	4	47.25
Error	254	5.93
Total	386	7.70

Table 80. Analysis of variance for number of pigs weaned from Yorkshire x Landrace sows fed individually and group-fed combined

Source of variation	Degrees of freedom	Mean square
Feeding method	1	12.68
Sows within ration	127	9.57
Litter order within feeding method	4	78.35
Error	254	7.24
Total	386	8.76

Table 81. Analysis of covariance, weaning weight adjusted for number weaned, for Yorkshire x Landrace sows group-fed

Source of variation	f	x^2	xy	y^2	f	Deviations from regression Adjusted y^2	Mean square
Sows w/rat	44	425.26	-128.78	172-75	43	133.75	3.11
Gest. x sows w/rat	88	471.36	-114.03	352.64	87	325.05	3.73

Table 82. Analysis of covariance, weaning weight adjusted for number weaned, for Yorkshire x Landrace sows individually fed

Source of variation	f	x^2	xy	y^2	f	Deviations from regression Adjusted y^2	Mean square
Sows w/ rat	75	669.91	-53.74	371.20	74	366.89	4.96
Gest. x Sows w/ rat	150	898.17	-84.16	381.43	149	373.54	2.51

Table 83. Analysis of covariance weaning weight on number weaned for Yorkshire x Landrace sows individually fed and group-fed

Source	f	Adjusted y^2	Mean square
Sows w/in rations	118	513.53	4.35
G x S w/in R	237	705.38	2.98

Table 84. Experiment 6435 - summary of the mean values for number of pigs farrowed, number of pigs farrowed alive, the number of pigs weaned and weaning weight

Feeding method	Individual	Group
Number of animals	240	147
Average number of pigs farrowed	11.7	10.8
Average number of pigs farrowed alive	10.7	9.9
Average number of pigs weaned	8.1	7.8
Number of animals	228	135
Average weaning weight (lb.)	8.5	9.2